JUL 28 1947

THE AUGUST SCIENTIFIC MONTHLY

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PUBLISHED BY THE SCIENCE PRESS
LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.
FOR THE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SMITHSONIAN INSTITUTION BUILDING, WASHINGTON, D. C.

NEW BOOKS OF SCIENTIFIC INTEREST

Reports of the Greenland Expeditions of the University of Michigan. Part II, Meteorology, Physiography and Botany. W. H. HOBBS, editor. Illustrated. 287 pp. $5.00. 1941. University of Michigan.

This concluding volume of the University of Michigan Greenland reports comprises scientific studies within the fields of meteorology, aerology, physiography and botany. The studies are based upon field work undertaken in two administrative districts of Greenland.

The Last Million Years. A. P. COLEMAN. Illustrated. xii + 216 pp. $3.50. 1941. University of Toronto.

A history of the Pleistocene era of geologic time in North America, with particular reference to the glaciation period. Events in the Mississippi Valley, the lake region, the Rocky Mountains and northern Canada are discussed separately.

Meteorology for Aviators. R. C. SUTCLIFFE. Illustrated. xiv + 276 pp. $4.00. 1940. Chemical Publishing Co.

The aim of this book is to present in a compact form those aspects of meteorology which are important in aviation. It is the first attempt at a textbook in that field. The treatment is mainly descriptive with mathematical formulae avoided as far as possible.

Economic Geography. C. F. JONES and G. G. DARKENWALD. Illustrated. xii + 629 pp. $4.25. May, 1941. Macmillan.

This material is presented by types of industries: hunting, fishing, gathering forest products, grazing, farming, mining, manufacturing, transportation and trade. The relation of physical factors and economic conditions to the production and distribution of the world's leading commercial products are emphasized.

So That's Astronomy. R. R. BAKER. Illustrated. 126 pp. $1.00. 1941. Reilly and Lee.

A book designed for children concerning different phases of astronomy. The "Old Professor" arranges a series of imaginary trips in his "space car" to the sun and to the moon and the rest of the planets, and describes what he discovers. An attempt at scientific accuracy is maintained throughout.

The Psychology of the Physically Handicapped. R. PINTNER, J. EISENSON and M. STANTON. Illustrated. 391 pp. $3.00. March, 1941. Crofts.

In the first section, personality development, mental hygiene, internal mechanisms of behavior and psychological tests for the handicapped are outlined, followed by a more detailed discussion of the nature and treatment of each of several handicapped groups.

Soldering for Workshop, Farm and Home. J. BONERT. 111 pp. $1.25. 1941. Orange Judd.

The author writes especially for farm boys and men with home workshops, on soft soldering and on brazing with silver alloys. A number of elementary instructions and projects are incorporated together with descriptions of common metals.

Before Your Eyes. D. R. BARTON. Illustrated. 64 pp. 1941. Row, Peterson.

A popular account of the work in a museum of natural history with particular emphasis upon the preparation of specimens for exhibit and the arrangement of habitat groups. The viewpoint of the public is stressed throughout.

The Factors of the Mind. C. BURT. xiv + 509 pp. 1941. Macmillan.

The author hopes to show that factor analysis is merely a refinement of a simple logical procedure. He wishes to create an appreciation of the logical method in psychology especially in the spheres of education and vocational guidance.

Civil Air Defense. A. M. PRENTISS. Illustrated. xv + 334 pp. $2.75. May, 1941. Whittlesey House.

A treatise on the protection of the civil population against air attack. Explosive and incendiary bombs, shelters, aircraft warning, rescue, first aid services and other aspects of air raid precautions are discussed.

More Years for the Asking. P. J. STEINCROHN. xii + 218 pp. $2.00. 1940. Appleton-Century.

The author presents a number of suggestions as to how to increase the length of one's life. Emphasis is placed upon the ideal patient-physician relationship and upon preventive measures for a number of common diseases.

Electric Eel Calling. SHELBY SHACKELFORD. Illustrated. x + 298 pp. $3.00. April, 1941. Scribners.

A physicist's wife tells the story of her husband's expedition with a biologist to the Amazon in search of the electric eel. Observations and recordings of their experiments on electric eels are recorded in a popular way, but the book is primarily about the country and the people.

A Guide to Guidance. C. SMITH and MARY ROOS. xvi + 440 pp. $3.00. January, 1941. Prentice-Hall.

A manual for persons interested in vocational guidance, covering such topics as: intelligence and occupational effectiveness, individual attitudes and drives, the organization of guidance services and the part high schools can play both in the curriculum and in selecting occupations.

Natural Science in German Romanticism. A. GODE-VON AESCH. viii + 302 pp. $3.00. May, 1941. Columbia University.

The author assumes that Goethe's scientific work can supply the key to all his thought, and with this assumption approaches the problems of the era in which Goethe lived, from the standpoint of the natural sciences.

THE SCIENTIFIC MONTHLY

AUGUST, 1941

GEOLOGICAL ASPECTS OF OUR NATIONAL PARKS

I. NATIONAL PARKS OF THE FAR WEST

By Dr. RAYMOND E. JANSSEN

EVANSTON, ILLINOIS

Our great National Parks are sections of the old American wilderness. They are as valuable, acre for acre, as the richest farmlands. They feed the spirit, the soul, the character of America.
—*Emerson Hough*

THE National Parks of the United States, primarily, are areas of scenic magnificence which have been set aside by Congress for the benefit of the people. Almost without exception, the natural features of these parks are unparalleled in the explored world. They have come to be recognized as supreme examples of their kind. Few nations can equal one or more of these masterpieces of nature, and none can boast of containing several of them. And America, too, has assumed leadership in making her countless wonders readily accessible to her citizens—to be enjoyed by rich and poor alike.

The United States can claim without fear of contradiction that she stands pre-eminent in her assemblage of scenic wonders. Yellowstone Park contains more and larger geysers than all the rest of the world together. The Grand Canyon of Arizona is the world's greatest example of erosion by running water. Mount Rainier has the largest single-peak glacier system known. Crater Lake is the deepest and bluest of the accessible fresh-water lakes of the world, occupying the bowl of a former great volcano. Yosemite has long been heralded as the world's most beautiful valley; the quality of beauty can not be measured mathematically, but opinions of world travelers tend to sustain Yosemite's claim. Carlsbad Caverns contain the largest series of underground passages yet discovered. The sheer sculpturing of the many colorful peaks in Glacier Park is not equaled elsewhere in the world. The giant monarchs of Sequoia National Park are the largest and oldest living things in the world. Hawaii National Park may boast the hugest active volcano in the world and the Kilauea Lake of Fire, which is, itself, unique. Mount McKinley in Alaska, also a national park, is scenically the world's loftiest mountain; although peaks of the Andes and Himalayas rise to greater heights, they can not be viewed closely except from valleys at least 5,000 feet higher than McKinley's.

Few, indeed, are the individuals who can gaze into the mysterious depths of the Grand Canyon, peer upward to the jagged heights of the Grand Tetons, or watch the spouting waters of Old Faithful without experiencing some inward sense of emotion—some feeling of awe and wonder at the marvels displayed before them. And yet, how many of these

individuals fully comprehend these amazing spectacles?

To most observers, scenery is a pleasing panorama of mountain chains, deep valleys, turbulent streams, plunging waterfalls, quiet lakes or trackless forests. To them, the glistening peak of Mount Rainier, the ice-gouged valley of Yosemite, the windowed walls of Bryce Canyon or the festooned caverns of Carlsbad are little more than scenery—scenery of such magnitude as to be at once incomparable and undescribable, mysterious and meaningless. And yet, upon those self-same valley walls and eroded mountain sides are the written pages of history, the mighty drama of a constantly changing world.

It was A. C. Seward, the English paleobotanist, who once said, "A knowledge of the past, however imperfect, adds to the attractiveness of the present." The truth of this statement is self-evident. It is one thing to gaze in awe across the great abyss of the Grand Canyon; but it is far more satisfying to view it in the light of history—to see upon its painted walls the shifting scenes of a pulsating continent, to see in its mysterious depths the motivating power of running water. It is one thing to gaze enraptured upon Glacier's ice-carved mountain sides; but it is much more thrilling to visualize in them the mighty upheaval which changed sea-bottom to mountain-peak, later to be gouged by the rasping power of creeping rivers of ice. It is one thing to see beauty in a hundred glacial lakes, perched high upon the cirque-etched cliffs; but it is an added experience to appreciate that they owe their continued existence to the morainic dams which hold them in their places.

Only through the application of knowledge can we fully appreciate and understand. To derive the fullest measure of

Courtesy U. S. Dept. of the Interior

MOUNT McKINLEY, HIGHEST MOUNTAIN IN NORTH AMERICA

LOOMING HIGH ABOVE THE GREAT ALASKA RANGE. IT RISES 20,300 FEET ABOVE SEA-LEVEL AND 17,000 FEET ABOVE THE GRAVEL PLATEAU IN THE FOREGROUND. EVERLASTING GLACIERS OF ENORMOUS BULK COVER THE MOUNTAIN'S SIDES.

satisfaction from the matchless beauty of our national parks, we must remember that in their present forms they are but ephemeral stages in a constantly shifting drama—a drama whose beginning was never witnessed by man, and whose end is nowhere in sight. To read even a portion of that drama is to add to the appreciation of our scenic wonders.

There are to-day 161 national parks and monuments, occupying more than 33,000 square miles of territory. These national reservations fall readily into two major classes—those which contain natural wonders and those of purely national historical interest. We are concerned here with only those national parks which contain scenic wonders of immense proportions. These may be further divided into several groups on the basis of their geological and evolutionary origins. Three distinct groups may be considered as including the mountain parks of the Pacific Chain, the Rocky Mountain Chain and the Appalachian Chain. Another group includes the desert and canyon parks of the arid Southwest. A fifth group embodies the subterranean parks, such as Carlsbad Caverns, Mammoth and Wind Caves. A final group includes national parks which are of interest solely because of their mineral springs, such as Hot Springs in Arkansas and Platt in Oklahoma.

The Pacific Mountain Parks

North America is bordered on the west by the Pacific Mountain System, a broad mountainous chain extending northwestwardly from Mexico to Alaska. At the head of Cook Inlet, it swings in a great arc to the southwest, extending to the end of the Aleutian Islands. This great arc is the massive Alaska Range, loftier than the Sierra Nevadas and greater in relief and extent than the Alps.

The central mass of the vast Alaska Range attains its climax in majestic Mount McKinley. It towers to a height of 20,300 feet, and on clear days the glistening peak can be seen from distances of 200 miles in all directions. Its upper two thirds are perpetually blanketed in ice and snow. This, the highest mountain in North America, was acquired with the Alaska Purchase in 1867. The mountain was surveyed by the United States Geological Survey in 1898, but its summit was not scaled until 1913. In 1917, Congress set aside the territory surrounding the mountain under the name of Mount McKinley National Park. It has an area of 3,030 square miles, and is our second largest park, exceeded in size only by Yellowstone.

The Pacific Mountain Chain had its origin in the great diastrophic movements which occurred at the close of the Jurassic Period, although the present elevations of these ranges are the results of subsequent uplifts, principally at the close of the Tertiary Period. These titanic deformations were intense throughout the chain, from the Aleutian Islands to Mexico. The great Alaska Range, as well as the Gold and Cariboo Ranges of British Columbia, were elevated at this time. Within the United States, the Coast Ranges, the Cascades, the Sierra Nevadas and the Klamath Mountains were born. Accompanying these major uplifts, great quantities of molten magma were welled up into the central portions of these ranges. This frozen magma stands out to-day as great batholiths of granite which have since been uncovered by erosion. Granite is one of the hardest and most common rocks. Because of its massiveness and resistance to erosion, it stands out in towering peaks, lofty ridges and sheer precipices, producing scenery quite different from that of sedimentary and extrusive volcanic rocks. The cores of our Pacific mountains, as well as those of the Himalayas and the Andes, are prevailingly granite. Our Pacific Mountain Chain contains a number of national parks whose exquisite scenery has been

Courtesy Southern Pacific Lines

THE CREST OF MOUNT WHITNEY, HIGHEST POINT IN THE UNITED STATES

UNLIKE THE ISOLATED PEAKS OF MANY OF OUR HIGH MOUNTAINS, IT REACHES ONLY SLIGHTLY HIGHER THAN THOSE OF ITS SURROUNDING NEIGHBORS. EROSION HAS CARVED THE SUMMIT AREA INTO A MASS OF JAGGED RIDGES AND PINNACLES.

carved in granite. Included here are Mount McKinley, Olympic, Yosemite, Sequoia and the newly established King's Canyon National Parks. In all these areas, erosion has worn through the upraised sediments and is now actively carving the granite core of the great Pacific Chain.

Within the United States, the Pacific Chain attains its zenith in the high Sierra Mountains which effect a mighty rampart for a distance of 450 miles along the eastern part of California. Here the massive granite block has been carved during millions of years of erosion into an infinite variety of towering domes and pinnacles, deep canyons and sheer cliffs. The variety of granitic scenery here is remarkable because of the abundance of waters—not rain, but melted snows—which have supplied the cutting power of innumerable streams. Added to this, has been the gouging action of glaciers which moved down from the heights during the Great Ice Age. Amid this setting is Mount Whitney, 14,495 feet in altitude, the highest point in the United States.

Yosemite, Sequoia and King's Canyon National Park (including the former General Grant National Park) constitute a cross-section of the western slope of the Sierra Nevadas. These three closely adjacent parks include over 2,500 square miles of territory, containing some of the most magnificent scenery and the grandest forest trees of all the world.

Yosemite, acknowledged as the most beautiful of our national wonderlands, takes its name from the Indian language. To the Red Man, Yo Semite—the Grizzly Bear—was king of the forests, even as Yosemite to-day is heralded as king of natural beauty. Its colossal masses of granite (El Capitan and Half Dome), its sheer rock walls rising precipitously

above peaceful valley floors, its gleaming glacial-polished surfaces and its dashing ribbon-like waterfalls all combine to present those qualities which are deemed most beautiful in the eyes of man. And yet, to look upon such scenes as these without reading there the drama of their creation is to miss a great part of the picture.

Etched to a depth of over 2,000 feet in solid granite may be found the epic of Yosemite's eventful history. It was Francois E. Matthes, of the United States Geological Survey, who first grasped the full significance of the drama written on those rocky walls. He discovered that the main range of the Sierra Nevadas had been elevated steadily over a long period. The Merced River, armed with sand and boulders, catapulted down the slopes, cutting a deep valley into the granite as the great block was being lifted. The result was a master V-shaped river valley, with lateral steep-graded valleys entering it at various points. Then came the great glacier, moving slowly down the valley.

Courtesy Santa Fe Railway

YOSEMITE FALLS

HIGHEST IN NORTH AMERICA, PLUNGES FROM A "HANGING VALLEY" WHICH WAS LEFT PERCHED UPON A SHEER CLIFF WHEN THE GREAT GLACIER SCOURED OUT THE MAIN VALLEY.

At its maximum, the ice came within 700 feet of the top of Half Dome. It overrode Glacier Point, extending below El Portal for about a mile. The ice deepened the valley 500 feet at the lower end and as much as 1,500 feet in the upper portion near Glacier Point. Also, the valley was widened 1,000 feet at the lower end, and 3,600 feet at the upper. The mouths of the various lateral valleys were truncated and left suspended as hanging valleys, perched high upon sheer cliff walls. The lateral streams now reach the Merced River only by plunging over dizzy falls, several of which rank among the highest in the world.

It was long thought that Yosemite Falls, plunging downward for 2,565 feet in a series of two cataracts and several intermediate cascades, was the world's highest; and in much of the literature it is so recorded. But the work of the scientist and the surveyor is never done. We now know that one other, at least, is higher. This is Angel Falls in Venezuela, which makes a single plunge of more than 3,300 feet. If we consider sheer drops only, without taking into account the intervening cascades, then three more known waterfalls are higher than Yosemite's sheer falls of 1,750 feet. These are Kukenaam Falls, also in Venezuela, Sutherland Falls in New Zealand and Tugela Falls in South Africa. But lest we tend to diminish our own glory too quickly, let us remember that the seven highest waterfalls of Yosemite Valley rank among the first forty-seven of the highest known falls of the world. And our seven falls are all within a distance of ten miles from each other! A water spectacle such as this can be seen nowhere else in the world.

The late Tertiary uplift of the Pacific

Courtesy Chicago and Northwestern Railway

MOUNT RAINIER SLUMBERS BENEATH PERPETUAL BLANKET OF ICE AND SNOW
ONCE A BELCHING VOLCANO, NOW UPON ITS SIDES IS THE GREATEST SINGLE GLACIER SYSTEM IN THE UNITED STATES.

Chain was accompanied by intense volcanic activity. At many points the upwelled magma pushed through the folded and broken sedimentary layers. The Cascade Mountains, from Washington to California, were folded into a broad arch, and upon this platform are perched numerous volcanoes which once blazed forth as fiery beacons along the shores of the broad Pacific. Mount Hood, Mount Adams, Mount Baker, Mount St. Helens, Mount Rainier, Mount Shasta and Mount Lassen are a few examples. Some, like prehistoric Mount Mazama and Mount Tehama, long ago blew themselves away, and we see to-day only remnants of their former magnificence.

Among our many volcanic mountains, Mount Rainier is heralded as the grandest. Rising to a height of 14,408 feet, it is the third highest mountain within the United States. It stands 11,000 feet above its immediate base and covers 100 square miles of area. Its colossal magnitude dwarfs the surrounding peaks which, themselves, average more than a mile in height. The inclination of its flanks indicates that at one time it probably reached an altitude of 16,000 feet.

Like all volcanoes, Mount Rainier was built into a cone-shaped mass with materials ejected from its own interior—cinders, lumps of lava and flows of molten magma which solidified into hard layers of andesite. It is believed that a great explosion blew away the uppermost part of the original cone, reducing its height by about 2,000 feet. Within the remaining crater, which is nearly three miles in diameter, two smaller cinder cones were later built up. They rise about 300 feet above the old crater rim and form the present summit of the peak. Mount Rainier has had no great

Courtesy Southern Pacific Lines

CRATER LAKE NOW FILLS THE ENORMOUS CHASM OF A FORMER VOLCANO

ENCIRCLED BY THE BLASTED WALLS, RISING ABOVE ITS MIRRORED DEPTHS IS WIZARD ISLAND, FORMED BY THE CONE OF A SECONDARY VOLCANO WHICH AROSE WITHIN THE SHATTERED REMNANT OF THE FIRST.

eruptions during historic periods, but Indian legends tell of one, the date of which is unknown. Although the volcano is now dormant, considerable heat still remains within its reservoirs. Small jets of steam still issue from the summit, and warm springs flow from its sides. Mount Rainier has been a national park since 1899.

Mount Rainier is most famous for its extensive glacier system. Its 28 glaciers approximate 48 square miles in area, an expanse of ice far in excess of that on any other single peak in the United States. Several of these glaciers are from four to six miles in length. They vie in magnitude with the outstanding glaciers of the Alps, among which only one—the Aletsch Glacier — is much greater in size. Six of Rainier's great glaciers seem to originate near the peak, but others have their sources in the snows which accumulate in the bowl-shaped cirques on the mountain's sides.

The scenic effects resulting from the action of mountain glaciers can not be fully appreciated unless the function of the glacier is understood. At the uppermost extremity, or source, the ice freezes against the rock wall of the mountain. As the glacier moves forward, it pulls away—or plucks out—masses of rock which are then carried along with the body of moving ice. The resulting cavity behind the ice is then refilled with freshly fallen snow. This, in turn, becomes compacted into ice and freezes to the rock wall. Continued forward movement of the ice mass, and continued refilling of the crevice with new ice, repeated during innumerable ages, gradually plucks away the rocky mass of the upper mountain heights. Frequently the rock is undermined so that great chunks fall from the upper wall upon the ice and are also carried away. A precipice is left, often sheerly perpendicular. As the process continues, the precipice itself is cut backward into the very heart of the mountain peak. Such precipices are usually in the shape of an arc, or half circle; hence the name cirque —the starting point of the glacier.

As a glacier moves down the mountain, it also widens and deepens the valley through which it moves, the results of which are so vividly portrayed in Yosemite Valley. Such erosion is largely the result of freezing and plucking away of rock along the sides and bottom of the ice mass. Rocks which are frozen in the under surfaces of the ice act as rasps which scrape along the valley floor. After the glacier has melted, these rasp scratches, or striae, may be seen upon the rock surfaces over which the ice has passed. They provide a criteria in determining the extent and directional movement of former glaciers.

At the lower extremity of a glacier, where the ice is melting, erosional activity is replaced by depositional activity. The rocks, gravel and sand which have been carried down by the moving ice are dropped as it melts. The heaps of resulting debris, or moraines, frequently act as dams and give rise to impounded lakes which are fed by the melting ice-water. As the glacier melts back through successive stages, a long series, or chain, of lakes may thus be formed, each held back by an individual moraine. The highest ones may occupy the actual cirques at the very sources of the former glaciers. Cirque lakes, perched high upon a mountain, and nestled beneath sheer cliffs on one side and held back by low moraines on the other, present many of our beautiful mountain vistas.

Among the innumerable quiet lakes which decorate our Pacific wonderlands, there is one of extraordinary significance. It is not a glacial lake, and the story of its origin is one of the outstanding epics which geology has revealed. Located in southern Oregon, on the very crest of the Cascade Range, is Crater Lake, occupying the bowl of a great volcano long

Loomis Photo, Courtesy National Park Service

EFFECTS OF TREMENDOUS MUDFLOW WHICH DESCENDED LASSEN PEAK ON MAY 19, 1915, PRECEDING THE MAIN ERUPTION, MAY BE SEEN IN THE DEVASTATED AREA WHERE MUCH OF THE FOREST WAS COMPLETELY DESTROYED.

since blown away. Mount Mazama, as it is called, was one of the mighty volcanoes which lighted the midnight skies after these ranges were elevated during the Tertiary Period.

The volcano was built up principally by lava flows, poured out layer upon layer, until a cone 14,000 feet high was attained. Glaciers moved down its sides, carving U-shaped valleys upon its flanks. And then, accompanied by a violent explosion, the volcano seems literally to have boiled over. Frothy lava rushed down the glacial valleys and overflowed the surrounding lowlands for distances up to 35 miles. This lava seems to have poured forth at terrific speed, for much of the molten material did not begin to solidify until it was four or five miles away from the crater. Accompanying these outpourings, or shortly thereafter, fissures developed along the mountain flanks, and the weakened dome collapsed within itself. The yawning crater which we see to-day is all that is left of the former towering Mount Mazama.

When Mazama collapsed within itself, there was intense reaction within the pit. The crumbling lavas choked the huge vent. In three places within the crater, small new volcanoes were born. Eventually these died and cooled. During succeeding ages, rain and snow blown into the huge crater formed Crater Lake. The rising waters covered two of the small volcanic cones; the third, called Wizard Island, is still emergent. The lake has no inlet, and except for seepage, there is no outlet.

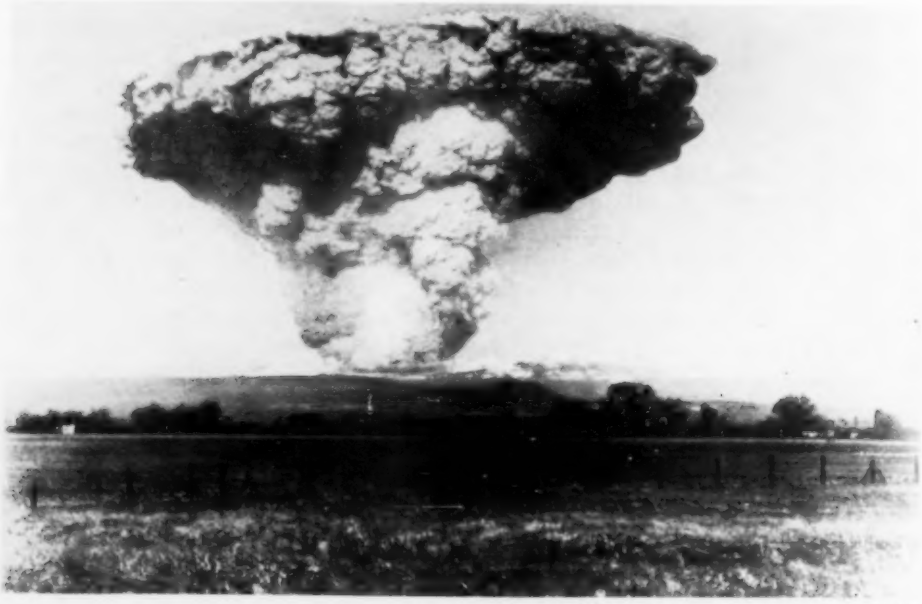
Such a lake was made possible only by a combination of conditions rarely equalled. These involved the building and collapse of a mountain to form a large, deep cavity having no surficial inlet or outlet. Evaporation, seepage and precipitation are in a perfect state of balance, allowing the maintenance of an almost static water level. Had any of

these conditions varied in slight degree, the lake might never have been formed. An analogous situation exists in the great Haleakala of Hawaii, which is also a collapsed crater. But here no deep lake fills the crater, and most of the bowl, 19 square miles in area, is arid.

Crater Lake has an area of 20 square miles, is six miles in diameter, 2,000 feet deep, and has a circular shore-line of 26 miles. The surrounding lava cliffs—the rim of the crater—rise from 500 to 2,000 feet above the water surface. The intense blueness of the deeper water, contrasted with the green of the shallower water around the margin, is recognized as the lake's most attractive scenic feature. This coloring is attributed to the scattering of light in water of unusual depth and clearness, just as the blueness of the sky results from light passing through the wide expanse of the atmosphere.

Crater Lake was discovered in 1853 by a party in search of gold. In the gold rush excitement of those times, the existence of the lake was forgotten for many years. In 1862, and again in 1865, it was "rediscovered" by parties who each thought theirs was the initial discovery. Not until 1885 did the lake become generally known. Finally, in 1902, Congress established Crater Lake National Park.

Among the many volcanoes which burst forth along our Pacific coast during the closing days of the Tertiary Period, only one is still active to-day. This is Lassen Peak at the southern end of the Cascade Range in northern California. Here the volcanic activity has been so recent that there has been little time for modification of the mountain by erosion. Although Lassen Peak has been glaciated, the effects have been largely concealed by volcanic activity which continued after the close of the Pleistocene glacial epoch.



Loomis Photo, Courtesy National Park Service

THE GREAT ERUPTION OF LASSEN PEAK ON MAY 22, 1915

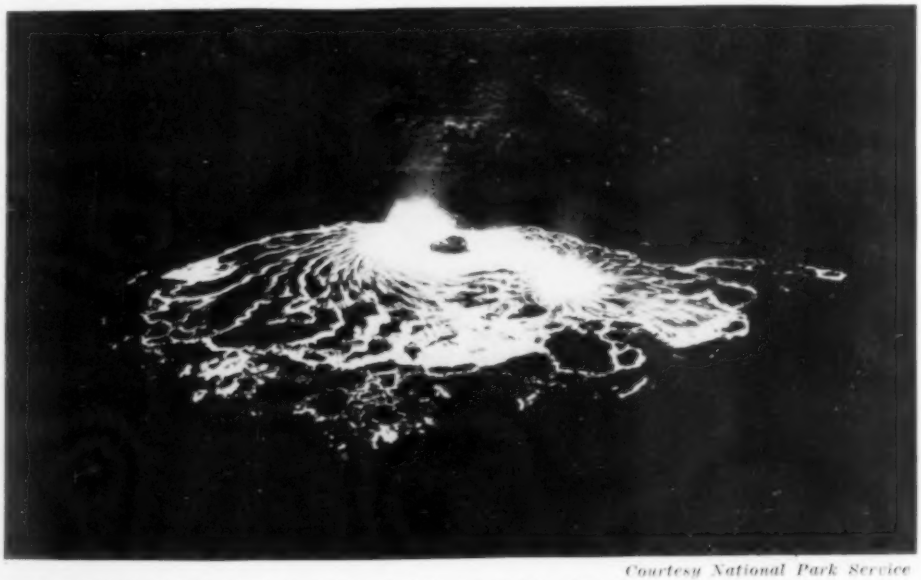
AS SEEN FROM A DISTANCE OF FIFTY MILES. THIS ENORMOUS CLOUD OF STEAM AND ASH ROSE TO A HEIGHT OF FIVE MILES ABOVE THE CRATER.

The great volcano, rising to a height of 10,453 feet, has passed through two stages of growth. The earlier mountain was a broad, gently sloping mound of lava beds occupying a base from five to seven miles in diameter. Its successive lava strata rose to a height of about 8,500 feet. In the second stage, the present steep cone was built up on this previously established lava platform. This cone was formed of stiff, viscous lava which was forced up through the vent, piling up around the old crater in a dome-like mass. Movements and weathering caused huge blocks of the solidified material to break away from time to time, causing enormous rock slides which accumulated about the cone as the mountain was still growing. To-day this mantle of rock talus reaches almost to the summit.

A series of eruptions between the years 1914 and 1917 was the latest spectacular activity of Mount Lassen. The materials thrown out during the first year were not hot, most of them not even melting the snows upon which they fell. However, on May 19, 1915, glowing lava spilled over the western rim of the crater, extending in a long tongue for 1,000 feet down the slope. On the northeastern slope much snow was melted, causing great mudflows which swept massive boulders weighing up to twenty tons into the valleys five miles away. A few days later, a terrific gas explosion shot dust and rock fragments down the northeast flank. The superheated blast destroyed or withered all vegetation for ten miles along its path. Simultaneously, a column of steam and ash rose to a height of five miles above the crater.

A final explosion occurred in June, 1917, after which the volcano again subsided into smoldering dormancy. Future eruptions may be expected, of course, but it is probable that the volcano is slowly dying—the last of a mighty chain of fire mountains that once blazed along our western shores.

Lassen Peak was originally designated a national monument by President Taft



Courtesy National Park Service

PERIODICALLY ERUPTIVE GREAT FIRE PIT OF HALEMAUMAU

AT TIMES IT BECOMES A CHURNING MASS OF WHITE-HOT LAVA, SHOOTING FOUNTAINS OF LIQUID FIRE HIGH INTO THE AIR.

Pan-Pacific Press Photo, Courtesy Matson Navigation Co.

THE CRATER INTERIOR OF HALEAKALA IS LARGELY A DESERT WASTE

UNLIKE MOUNT MAZAMA OF CRATER LAKE FAME, AT THE EXTREME LEFT MAY BE SEEN THE CRATER OF A SECONDARY VOLCANO, COMPARABLE IN ORIGIN TO THAT OF WIZARD ISLAND IN CRATER LAKE.

in 1906. Doubtless, there would have been no change in its status had not the eruptions of 1914–15 centered the eyes of the nation upon it. Consequently, in 1916, Congress established Lassen Volcanic National Park.

Truly active volcanoes, however, exist in our Hawaiian Islands. Most celebrated are Kilauea and Mauna Loa, which, together with dormant Haleakala, constitute Hawaii National Park, established in 1916. The great dome of Mauna Loa towers 13,680 feet above the waters of the Pacific, which is 16,000 feet deep at this point. The width of the mountain's base is unknown since it extends beyond the depths of exploration. But the volcano's total height, approximating 30,000 feet from base to peak, makes it actually one of the tallest mountains of the world. It is the largest active volcano, and has poured out more lava within the past century than any other in existence.

Kilauea seems to spring from the flank of monstrous Mauna Loa, but actually is a distinct volcano. Although only a little more than 4,000 feet in altitude, the crater of Kilauea is slightly larger than that of Mauna Loa.

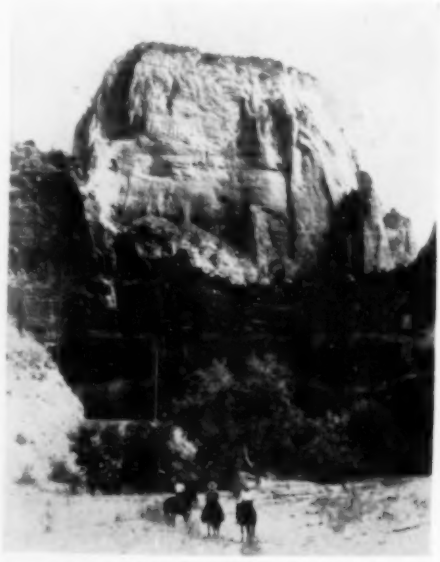
Within the crater of Kilauea is the fire pit of Halemaumau, "The House of Everlasting Fire." Correctly translated, however, the name means "House of the Maumau Fern," a native species bearing leaves that are contorted and twisted like certain forms of lava. When active, this lava lake is one of the most spectacular demonstrations on earth. The white-hot glowing masses of lava sometimes subside to depths of a thousand feet, and again they boil upward to the rim, occasionally overflowing it. At times, roaring jets of lava shoot upward to heights of 150 to 200 feet.

Another section of Hawaii National Park contains dormant Haleakala, whose great crater, nearly eight miles in great-

Courtesy Union Pacific Railroad

NATURAL ARCHES AND WINDOWS

FORMED IN THE THIN WALLS OF BRYCE CANYON AT MANY POINTS. THE HARDER CAP ROCK REMAINS WHILE THE SOFTER ROCKS BELOW ARE FREQUENTLY ERODED AWAY.



Courtesy Union Pacific Railroad

EL GOBERNADOR

(THE GREAT WHITE THRONE) RISES 3,100 FEET ABOVE THE CANYON FLOOR OF ZION NATIONAL PARK. CARVED FROM MASSIVE SANDSTONE BY RUNNING WATER, THIS GREAT MONOLITH PRESENTS A DAZZLING SPECTACLE WITH ITS BRILLIANT RED BASE SURMOUNTED BY A GLISTENING WHITE DOME.

est diameter and 3,000 feet deep, is the fourth largest in the world. Only three known craters exceed it in size. One of these is in Japan, and two are in Italy. Haleakala, rising to 10,000 feet, was once much higher. But like Mount Mazama of Crater Lake fame, its great dome collapsed at some past time, and subsequent activity built up smaller cones within the great crater. With conditions of precipitation different, no great lake occupies the massive pit. Although some vegetation occupies the inner slopes, the vast crater is, for the most part, arid and barren.

The age of the Hawaiian volcanoes, from the time when they burst forth upon the floor of the Pacific, is not known. Geologically, however, they are quite young. In fact, Hawaii National Park, in point of geological age, might be considered as the infant of our great family of national park wonderlands.

The Canyon Parks

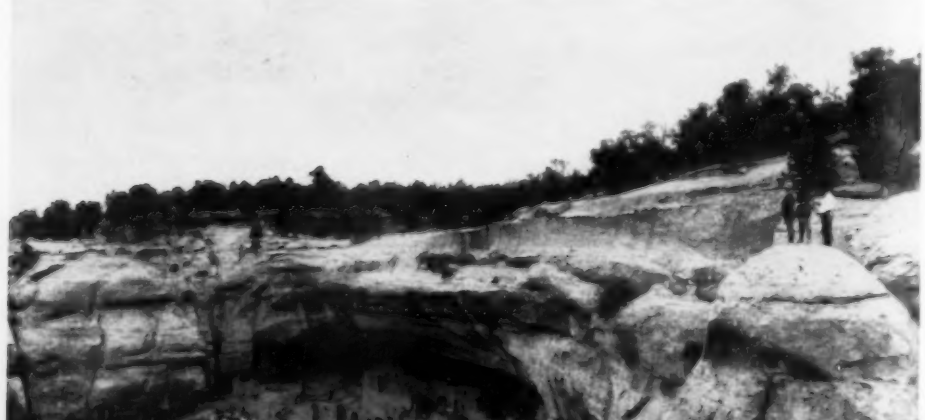
The magnitude of erosion by running water is nowhere more clearly visualized than in our great Southwest, where four national parks have been established. Nowhere else, in so limited an area, may be seen a greater sequence of the earth's stratified formations than are revealed upon the canyon walls of this vast region. Although many events of the world's history are not revealed in the formations of this region, at least some stages of each of the five great geologic eras have left their story here. From the Tertiary formations of Bryce Canyon to the ancient Archean granites at the bottom of the Grand Canyon, one may look backward through the reaches of time approximating, perhaps, a billion years of recorded earth history.

The four national parks of the Southwest—Bryce, Mesa Verde, Zion and Grand Canyon—may well be considered together because each represents a stage in a mighty geologic sequence. This sequence began when the Archean granites of this region were first flooded by the sea. Upon the floor of that sea were

Courtesy Santa Fe Railway

STEP AND PLATFORM TOPOGRAPHY IN ERODED DEPTHS OF GRAND CANYON

CAUSED BY UNEQUAL HARDNESS OF THE ROCK LAYERS. THE ALMOST LEVEL HORIZON MARKS THE SURFACE OF THE GREAT PLATEAU INTO WHICH THE DEEP CANYON HAS BEEN CARVED.



Courtesy Santa Fe Railway

PICTURESQUE APARTMENT HOUSES OF CLIFF DWELLERS

UTILIZING THE LEDGES, CARVED OUT BY RUNNING WATER, IN THE MASSIVE MESA VERDE SANDSTONE.

deposited the Proterozoic sediments which were later crumpled and folded into a mighty mountain range. Those mountains are now missing, for they were worn low in the ages which followed. Their roots, however, are still visible where they rise as small hills on a rather level surface of granite in the lower parts of the Grand Canyon. All the horizontal layers which lie above these buried hills are sediments which were laid down when the seas again encroached upon the land during the Paleozoic Era, the third great division of geologic time.

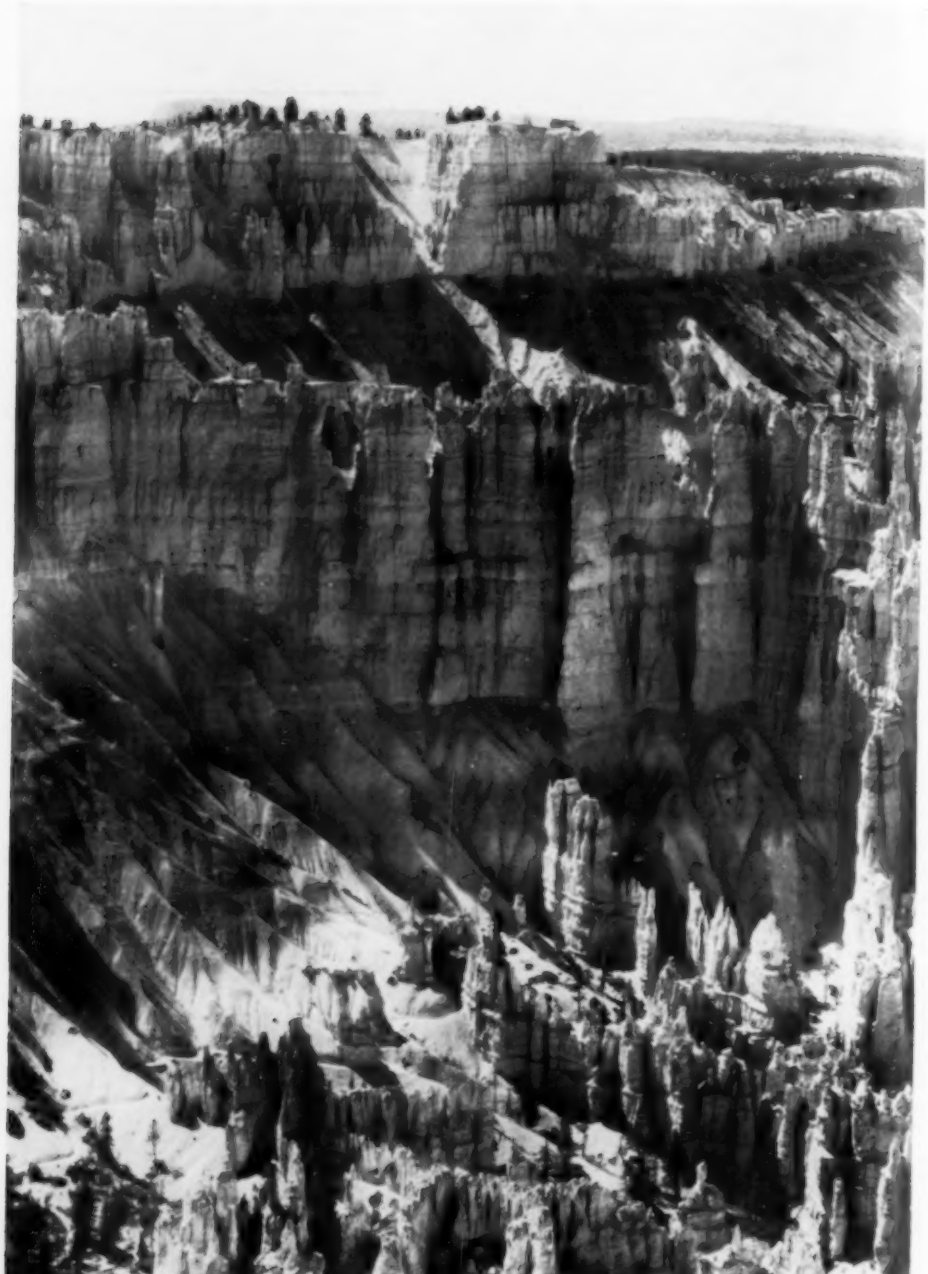
The rim, or uppermost, stratum of the Grand Canyon continues northwardly across the plateau and becomes lost beneath the overlying formations of Zion National Park which were laid down during the early half of the next succeeding era, the Mesozoic. Following the latter formations eastwardly to Mesa Verde National Park, one encounters rocks of the later, or upper, part of the Mesozoic Era. Here they are capped by a massive sandstone layer which provided protection for the picturesque structures of the Cliff Dwellers. Continuing back westwardly again to Bryce Canyon National Park, one finds the Mesozoic strata topped by the Pink Cliffs, laid down during the Tertiary Period, or early part of the Cenozoic Era—the last of the five great geologic divisions. And above these, in the region, are recent lava flows. Thus, in progressing from the bottom of the Grand Canyon, through Zion and Mesa Verde, to the top of Bryce Canyon, one passes through a greater sequence of geologic formations than in any other known area of equal extent.

The latest elevation of this great plateau region is thought to have taken place at the close of the Tertiary Period, just prior to the beginning of the Great Ice Age. The cutting of the Grand Canyon to a depth of a mile in this plateau, as well as that of the other canyons, was accomplished entirely by running water; ice played no direct part in this erosion. This cutting represents only a comparatively short duration of time in comparison to that required for the deposition of the strata themselves.

The Grand Canyon of Arizona has become the most famous canyon in the world. It is not, of course, the deepest known valley, nor quite the deepest canyon; but the combination of depth, length, width, steep-sidedness and coloring causes it to excel all others. In places there are sheer drops of 2,000 to 3,000 feet; elsewhere the canyon walls retreat in regular fashion, step by step, from the inner gorge to the rim. The various strata forming these steps vary in hardness, and hence, in their resistance to erosion. Each resistant bed stands out like a cliff, and each intermediate weaker bed is faced with a slope. The rim of the canyon is composed of the hard, massive Kaibab Limestone which extends for many miles in all directions.

The Colorado River, as viewed from the rim of the Grand Canyon, appears quite insignificant. Actually, it is one of the great rivers of the world and the second longest in the United States. At the gaging station in the canyon, the river is 300 feet wide, its flow ranges from 2½ to 20 miles per hour, and its normal depth varies from 12 to 42 feet. The river is subject to sudden floods, with the volume multiplying several times in a single day, and the level rising accordingly.

The suddenness with which the river drops—14,000 feet from its source in the mountains of Colorado and Wyoming to its mouth—gives it enormous eroding power. Measurements show that about 1,000,000 tons of sand and silt are carried past the gaging station every 24 hours. Because of the aridity of the region, plants grow sparsely upon the slopes, providing little protective cover.



Courtesy Union Pacific Railroad

SANDSTONE FORMATIONS IN BRYCE CANYON NATIONAL PARK

THESE GROTESQUE SHAPES ARE THE RESULT OF EROSION UPON STRATA OF UNEQUAL HARDNESS.

Hence, spasmodic showers concentrate more energy here during a single torrent than might be realized during a full season's rainfall in a region of denser vegetation. For the same reason, the tributary streams are largely intermittent. The great elevation of the plateau, however, enables them to cut deeply during every infrequent storm so that the results of their cutting are gigantic in scale.

The carving of Zion Canyon by the Mukuntuweap River, a tributary of the Colorado, is essentially the same, except on a smaller scale. Bryce Canyon, however, is a great horseshoe-shaped amphitheater, or box canyon, three miles long and two miles wide. The rocks of Zion and Bryce canyons are among the most colorful of any which make up the earth's surface. They range from almost pure white to chocolate, with numerous intermediate shades of yellow, orange, pink and red. Dominant, however, is the pale rosy pink of the famous Pink Cliffs of Bryce Canyon.

Mesa Verde National Park is not, in itself, a single large canyon. It is rather a great plateau which has been partially dissected by numerous steep-sided valleys and canyons cutting into it in finger-like fashion. The small, intermittent streams which have cut these valleys are tributaries of the Mancos River, which, in turn, is a tributary of the Colorado. In working headwardly into the mesa, the streams have dug out narrow platforms and hollows along the faces of the sandstone cliffs. These were utilized by the Cliff Dwellers as sites for the construction of their dwellings. Interest in Mesa Verde is centered primarily in these cliff dwellings, which are among the finest known examples of their kind; yet one should not fail to appreciate that it was erosion which produced the sites for these unique structures.

(To be continued)

SCIENCE VERSUS LIFE

Now, I shall try to say in one minute what I probably failed to make clear in fifty. As I see it, ours is not an age of science. Men are still driven by greed and confused by guile, rather than guided by reason and justice based on our expanding knowledge. Science has greatly enlarged man's understanding, conquered many of his diseases, lengthened his life, multiplied his joys, decreased his fears, and added much to his physical comforts and powers. But man may use these and other achievements for a greater social injury, instead of for a further social advance. Science is specifically human, in that it stems from the innate curiosity of all men, and the conspicuously plastic brains of the ablest, if not the noblest, of our fellows. If this be so, it follows that the scientific method and its products can not be, in any fundamental and permanent sense, in conflict with human nature, though our present human society, product of a past dominated by greed, force and fear, may be, and is in conflict with the scientific method. Whether science and the scientific method, whether understanding, honesty, reason and justice can contrive survival values equal, if not superior to the blind forces of nature which shaped man's past, is as yet in the laps of the gods. Still, we can not deny the possibility, and we *will* nurse the hope, that the hairy ape who somehow lost his tail, grew a brain worth having, built speech and song out of a hiss and a roar, and stepped out of the cave to explore and master the universe, may some day conquer his own irrational and myopic behavior towards his kin.

I think we can say, even in the face of current pessimism, that during the ups and downs of past ages man has gradually acquired more understanding, more freedom from fear, more dignity, greater kindness and a clearer conception of justice. Even though for the moment, "the bird of sorrow" is not only flying over our heads, but is actually nesting in our hair—to borrow a Chinese proverb—that bird will not nest in our hair forever, even though a blackout on the light of science is decreed in every land. For slowly, but surely, the method of science will help to make life more intelligent, toil more cheerful, fear and hatred, pain and tears less prevalent in our lives. If in any place or time the blind fury of hatred of our brethren and the insane violence of war render the pursuit of science impossible, and the scientific method submerged and forgotten, it will be rediscovered, in better days, by better men.—*A. J. Carlson, Sigma Xi Quarterly, Vol. 28, No. 4, 1940.*

ZOOLOGICAL GARDENS. II

By Dr. ETHAN ALLEN ANDREWS

EMERITUS PROFESSOR OF ZOOLOGY, THE JOHNS HOPKINS UNIVERSITY

WHILE France developed its one chief zoological garden from the Jardin des Plantes, the earliest beginning (except one) of any in Europe, Germany gradually made several zoological gardens continuing on from more or less ancient beginnings.

In 1812, Frederick, the first king of Wortemburg, ordered a zoological garden near Stuttgart where already in keeping there, animals could be found about his royal pleasure house, in appropriate housing, and in 1814 the buildings were finished and contained 54 apes, three elephants, a tapir, a leopard, five bears, six buffalos, two quaggas, two beavers, two kangaroos, three armadillos, and 40 parrots, eagles, ostriches and other birds. But when Frederick died in 1816, his son, William, ordered the menagerie to be sold, since famine due to crop failure had fallen heavily upon his people. During more than a year the sale of animals continued and some were bought up by the king of Bavaria and the Grand Duke of Baden, thus strengthening various zoological collections in Germany.

This disperson of wild animals led to a memorable contest between man and beast wherein intelligence and force were not distributed to the great credit of man, for when the big elephant weighing 4,622 pounds was sold to the owner of a menagerie in Berlin for 3,300 florins, and was to be shipped to Venice on a coasting vessel, the bending of the gang plank made the beast hesitate about going on board at all. Repeated offers of food held out to tempt him to board so greatly excited the elephant that he desperately assaulted and killed his keeper and made a raid on the fruit stands. The military fired a salvo into the elephant, who thereupon ran down a blind alley, broke into a house and tried to climb the stairway until it broke under his weight. Repeated shootings collapsed the great beast, but he rose again and broke into the door of the Church of San Antonio on the bank of the Riva near Schiavoni, and in this sanctuary made some sort of defense by collecting benches about himself.

The end of this farcical tragedy was that on the next day the brave soldiers brought up a cannon and having made a hole in the wall of the church, fired a cannon ball into the body of the elephant. Its skeleton and skin went to the collection at Padua.

One of the first and greatest zoological gardens of Germany, that at Berlin, the third oldest in Europe, was preceded by the Jagerhof, founded in 1725 and containing aurochsen, bears, elks, seals, falcons, etc., and also by the menageries on Peacock Island, near Potsdam, where were kept monkeys, kangaroos, llamas, bears, wild swine, beavers, eagles and so on.

To build up a great zoological garden was the plan conceived by the traveler and zoologist, M. H. K. Lichtenstein, and this was to be located in the pheasantry at Charlottenburg. So he spoke to Baron Alexander von Humboldt and the latter laid the matter before the king. The king allowed the breaking up of his pheasantry and the donation of 407 animals that were then on the Island of Peacocks. Lichtenstein then formed "The Society of the Zoological Gardens of Berlin," and to this the state contributed $1,500 for five years without interest, but later at three per cent., and

subsequently the sum was raised to $25,000. The garden was carefully laid out in advance by the general director, Lenné, and the buildings were designed by Professor Strach and the architect, Cantian. It was opened to the public on August 1, 1884. At first Humboldt was on the commission that held control.

Growth at first was very slow; by 1868 the public had taken up only 191 shares at $75 each. And after the death of Lichtenstein in 1857, a period of stagnation set in until the new director, Dr. Bodinus, formerly director of the zoo at Cologne, set the great Berlin zoo on its feet permanently. In 1870 there were in this zoo more than 250 mammals, and 760 birds of 350 species, all estimated to be worth $40,500.

Successive directors were attracted from the zoological gardens at Frankfort and at Cologne. In 1900 the society placed the administrative work in the hands of one director, and the scientific work in the hands of a separate director. By 1907 this society enrolled 3,000 members and employed 115 persons in the garden. With some slight aid from the city they raised by entrance fees, and so on, $200,000 for annual expenses, and at that date the garden contained 3,149 animals belonging to 1,297 species.

In this Berlin garden was invented the plan to have the buildings characteristic of the countries in which the animals naturally lived, a scheme often difficult to execute without great detriment to the real value of the animals, which tend to be subordinated to gaudy and bizarre styles of architecture.

With concerts and other side attractions, there grew up one of the largest and most useful popular zoological gardens of Europe. Directors with much experience were drawn hither from

OSTRICHES ACCUSTOMED TO BEING KEPT OUTDOORS IN THE SNOW

BY CARL HAGENBECK AT STELLINGEN IN NORTH GERMANY. HAGENBECK IS APPRAISED BY PEEL AS "THE MOST OBSERVING, MOST SUCCESSFUL KEEPER OF LIVE ANIMALS IN THE WORLD." HE FOUND THAT MANY TROPICAL ANIMALS WOULD THRIVE IN HIS MOST ASTOUNDING ZOOLOGICAL PARK, IF GIVEN PROPER FOOD AND EXERCISE, FOR "THEY MUST HAVE FRESH AIR ALL THE YEAR ROUND."

SOME OF THE THIRTY-TWO HEAD OF EUROPEAN WILD BISON
AS SEEN IN 1907 IN THE VAST DOMAIN OF THOUSANDS OF ACRES IN UPPER SILESIA OWNED BY THE DUKE OF PLESS, DERIVED FROM ANIMALS BROUGHT IN 1865 FROM RUSSIAN POLAND.

other gardens. Dr. Heck increased the number of animals to 25,000, of 12,000 species.

In 1898 new shares were issued, bringing up the capital of the company to more than one-half million dollars and with statuary and all sorts of buildings and diversions added to the sight of the scientifically arranged animals, the people thronged to the garden to the number of 60,000 on a fine Sunday.

This great development was based upon two factors: the great love of the people for animals, and the interest of the Emperor of Germany—history repeating somewhat of the old menagerie of the City of Assur with, however, a very great advance made in the share due to the people.

A second zoological garden in Germany, at Frankfort, arose in 1857 when, after much discussion, a committee of eight men obtained from the Senate a law to establish a zoological garden with a capital of 50,000 florins in 200 shares of 250 each, non-taxable, members and families to have free admission. On the Bochenheimer pike 14 acres were rented for 10 years.

The next year the capital was doubled and all the shares were taken up before the opening on August 8, 1858. The membership increased: 1,052 in 1858; 1,382 the following year, most of the holders being families. Although at first there was not only a director in charge of the animals, but a scientific head, who started a publication, *The Zoological Garden*, in 1859, which was continued on into 1866, it was found that there was not much popular appreciation of the scientific side of the garden and so this aspect was discontinued for a time but is now in its third series.

The non-scientific point of view seems well shown in the emphasis at first put on the agreeableness of the exhibits to the senses; thus at first the carnivora

were excluded, for it was said in the prospectus that wild and flesh-eating animals could not be kept in a garden except in cages and belonged rather to a menagerie than to a garden; and moreover, such animals are of little interest, as being generally afraid of light they are asleep or hidden away by day and they generally assail the nerves of smell. How different are the possibilities to-day since the introduction of moated enclosures in the most progressive gardens! Nevertheless, this same appreciation of the esthetic in the zoological garden is one of its most commendable virtues to be duly cultivated and at a later date, 1903, this same garden was noted as one of the prettiest in Europe with its lawns, big shady trees, ponds and flowers.

Soon, however, the gifts of carnivora by people of Frankfort who had gone abroad led to the adoption of the usual classes of animals in this zoo, and the garden flourished materially. From 1858 to the end of 1883 the garden recorded 1,276,004 people visiting it.

After the wars, a new lease of life was given to the garden when, in 1872, a new Zoological Society was formed with a capital of 1,300,000 florins to accept the offer of the city of 37 acres in the Pfingstweide free for ten years, and then at an annual rental of 10 florins per acre.

The first tree was planted on the new site on March 24, 1873, and the old animals transported so that at the end of that year the garden contained 1,108 animals of 260 species, valued at 46,360 florins.

In a few years an aquarium was added. In 1900 the income had grown to more than $50,000; in 1905, to $64,000; and in 1906, about $80,000; and it occupied seventeen and a half acres with most carefully tended paths, lawns, flower beds, with many fine animal houses in which the animals thrived and bred, while especial attention was given to the many fine bird collections, both native and foreign. Strange to say, the garden possessed a remarkable collection of butterflies, about 25,000 specimens, in 1903. In 1905 they were keeping alive some 3,000 butterflies in the chrysalid state in the expectation that when they transformed into adults the people would enjoy the sight of many beautiful butterflies from India, South America and Africa—certainly a unique exhibit! In 1906 about 3,000 animals were in this garden.

In this Frankfort garden could also be observed on the wall the record of the increasing annual measurements of the African elephant from 1901 to 1906, 1.160 to 2.235 meters, recalling the old homesteads wherein like wall marks recorded the growth of children!

But in addition to these great gardens of Berlin, Frankfort and Cologne, already spoken of, others arose in Germany of various degrees of importance. Some we will merely enumerate, as at Breslau, Hamburg, Stellingen, Konigsberg, Stuttgart, Aix-la-Chapelle, Elberfeld, Duesseldorf, Muenster, Hanover, Leipzig, Dresden, Posen, Augsburg, Karlsrhue, Mülhausen, Nymphenburg, Halle, Heidelberg and even more.

Zoos in the Netherlands

Along with the activity shown in Germany and France there were developments of zoological gardens in other parts of Europe and in England.

In Holland the painters of the seventeenth century were able to portray animals in Paradise and in pictures of Orpheus in a much more realistic way than was possible in Italy, since in Holland the animals of foreign lands had become better known through extensive trading with America, Africa and Asia. As early as 1784, a 3,000 pound rhinoceros was sent from Bengal to Amsterdam. And in that period came the ending of a much loved inn, in Amsterdam, "*zum blauen Tau*," connected with

which there was a menagerie of importance.

Near The Hague in a castle, "*het Loo*," the hereditary ruler maintained a collection of curiosities and a menagerie, and the director in 1766–1784 published a list, with illustrations, of 31 remarkable animals brought from the colonies to this menagerie. This catalogue was translated into French by Renfer in 1767–1787, and again later published in Dutch in 1804.

It is related by Houel, in a history of the two elephants of Paris, that at the time of the French invasion, 1795, when the Dutch ruler was driven out, the animals at the Loo were carried off and added to the collections of the Jardin des Plantes.

In 1809, King Louis, of the house of Bonaparte, established a zoological menagerie that continued only thirteen months and then, on dissolution of the Kingdom of Holland, was sold at auction. Twenty years after this, upon the restoration of the monarchy under the House of Orange in 1835, an attempt was made to start a government zoological garden after the pattern of the great Zoo of London. The book dealer, G. F. Westerman, was the active agent in this movement. But it was not until 1838, on the founding of the society, "*Natura artis magistra*," that land was bought and the zoological garden opened in Amsterdam. In 1840 the famous zoological menagerie of Aken was purchased and added to the Amsterdam zoo, and Westerman was made the director in 1841. Since 1852 the society has been called "The Royal Zoological Society," and since 1847 it has published the scientific journal, "*Beitragen tot de Dierkunde*."

Rotterdam also developed its zoological garden, and there were gardens in Antwerp, Brussels, Ghent and Liége, while others sprang up in all parts of Europe, as at Madrid, Basle, Buda-Pesth, Kopenhagen, Moscow and at St. Petersburg and Rome.

Something of the sequence in founding these various gardens will appear later, but we must not overlook such activities in the British Isles and the great collections in the zoo near London.

British Zoological Gardens

The first zoological garden, in the strict sense of the term, developed from the so-called Knowsley menagerie of the Earl of Derby at Knowsley, England. Its elephant folio, for private circulation, is entitled "Gleanings from the Menagerie and Aviary at Knowsley Hall. Hoofed Quadrupeds. Knowsley 1830, with 59 plates painted, or else printed, in colors, lithographed with notes by the Earl of Derby, and published by John Edward Gray."

On the death of the earl this collection of animals formed the basis for the Regent's Park Zoo, the great real "zoological park" of the Zoological Society of London. This famous society began in 1826 at the suggestion of the president of the Royal Society, Sir Humphry Davy (who died in 1829), and the geographer, Stamford Raffles (who died in 1826). The objects were to advance zoology, and to introduce into England new and remarkable animals. It thought to establish a museum of stuffed animals and a permanent menagerie in which should be kept all foreign birds, mammals and fish that could possibly be tamed.

This idea met with approval. In 1829 the members of the society paid fees to the amount of more than $8,000 and rented from the Crown some thirty-one acres in Regent's Park. They placed the animals partly in houses and partly in the open, and first applied the term, Zoological Garden. These collections and the numerous publications arising as the scientific work of the society furnished the starting point for a great advance in zoology in England. In ten

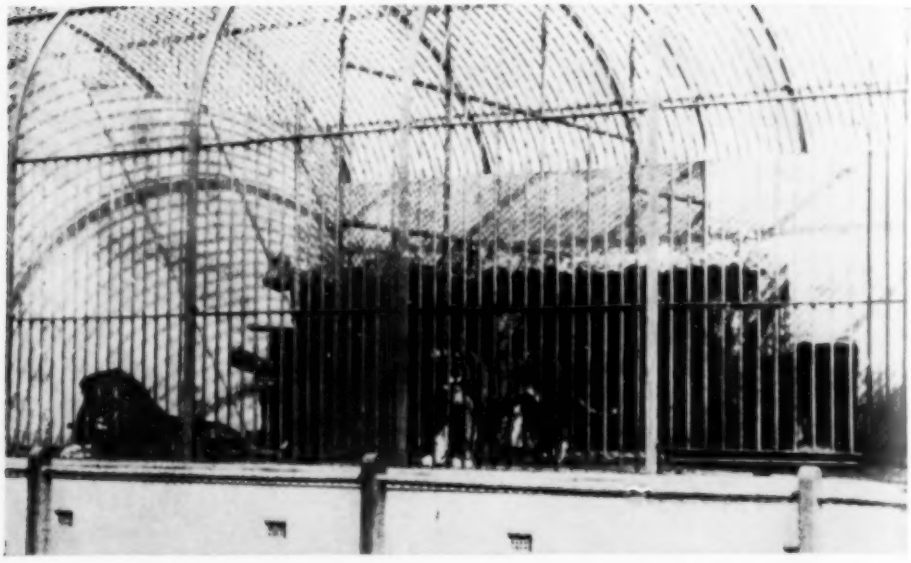
years after the beginning, the society had 3,011 members, each paying $15 yearly, and an initiation fee of $25. The garden contained some 1,000 different sorts of mammals and birds. Non-members paid a shilling a visit, and this made a revenue of $30,000, the entire revenue being $75,000.

By 1905 this garden of a great society contained nearly 3,000 kinds of vertebrate animals. By the year 1923 the number had become more than three thousand.

Between five and six thousand members of the Zoological Society of London paying $80,000 fees, with $250,000 admission fees, brought the total income up to well toward a half million dollars, and left a surplus of some $60,000.

The more recent expansion of the London Zoo over a large area of countryside in which man, the visitor, is, as it

THE COLLECTION IN PRINCELY PARK, "HET LOO," IN HOLLAND
IN TIME OF WILLIAM III, MIDDLE OF THE 18TH CENTURY, AS PAINTED BY MELCHIOR D'HONDECOETER.



LIONS AS SEEN BUT POORLY EVEN IN THE BEST OF IRON CAGES
FROM THE 1939 REPORT OF THE ZOOLOGICAL SOCIETY OF VICTORIA, AUSTRALIA.

were, the enclosed creature and the animals more free to roam, is worthy of all praise and emulation. Although this zoo is so large and the isles so small, there are other zoos, as at Woburn and Manchester, Dudly, Bristol (Clifton), Paignton, as well as the aquaria in Brighton, Stibbington Hall, Blackpool, Liverpool and London.

Our history shows these modern animal gardens grew out of the ancient menageries that were chiefly for the enjoyment of the wealthy overlords, but gradually grew to be shared more and more with the common people, until finally they were given up exclusively to the populace for enjoyment and education.

But Europe had other uses for strange animals and one of importance was a more or less serious attempt to try out the possible practical gains to be had by taming wild animals to add to the comparatively few domesticated animals we have inherited from antiquity with, alas, so very few additions. Acclimatization and utilization of exotic animals seem most worthy of encouragement when we consider the virtues of many beasts and fowls that are in danger of extinction.

The European parks for acclimatization were essentially zoological gardens hoping to add to the nation's wealth rather than merely to the people's pleasure.

Parks for Acclimatization

Along with the various menageries and parks that may be called zoological gardens, there have arisen a few similar institutions whose chief objects have been to see how far it may be possible to introduce exotic animals and make them of use as domestic animals.

The first in point of time was the unsuccessful attempt to domesticate the dromedary at San Rossore, an hour from Piza. Here the dromedary was domesticated on a farm with fine pine forests founded by the Medicini, probably under the Grand Duke Ferdinand II of Tuscany, 1621–1670. In the first report in 1690, it is stated that six pairs had

been brought from Tunis, but only seven animals remained. In 1738 and 1739 seven more pairs were brought from Tunis by the Grank Duke Francis II. In 1784 there were as many as 170 dromedaries, and in 1789, 196. More than $300,000 were spent in purchasing dromedaries at Livorno and three men of Tunis were employed in caring for them.

According to an account published by the Swedish consul at Livorno in 1840, these dromedaries had free range over twenty miles of land, stockaded on one side, and bounded by rivers and the sea elsewhere.

Divided into workers, breeding females and foals, they were herded morning and evening by mounted guards. Most of the year they sought out their own food, but the breeding females were fed hay in huts, in December. The females continued to breed up to the age of twenty-one years and some lived here as much as thirty years. The young males were put with the working animals and, being tied, fed and cleaned by men became tamed and then broken to saddle and taught to kneel down. From November to May the workers were kept in stalls; they drank but once a day and ate half the food and did double the work of horses, which were not well adapted to the loose, sandy soil; while the camels, led in groups of three by one man, carried much building material and agricultural apparatus.

In 1840 the animals numbered 171, 91 male and 80 female, of which one was a breeding male, 58 breeding cows, 66 workers, 39 foals and seven young calves.

Here may be mentioned the domestication attempts in Australia, where the camel was of use in opening up the dry interior country.

This idea first arose in the London Geographical Society in 1844, when in the presidential address of Sir Robert Murchison the need of the camel to make possible the penetration into the interior was mentioned, and in the explorations of Sir Horrocks in 1846 one camel was taken, but it was not until 1860 that they were used in numbers in the expedition of Burke from Melbourne to the Gulf of Carpentaria, the Government of Victoria buying 25 camels from India for $25,000. The following year one of these camels was used by Mackinley in searching for Burke's party. Thomas Elder, one of the richest landowners in South Australia, sent to India in 1866 and successfully imported 121 out of a shipment of 124 camels, along with a dozen African grooms. It was found that the camels reached high and flourished on vegetation the horses and cattle could not get at, and throve upon all sorts of green plants, although they were made sick by some plants, especially *Gyrostemon romulosus*.

At ten years the young was like a four-year-old, and could be used thirty years or more. Moreover, the usual whipping the colonists bestowed on oxen had to give place to kind treatment, since the furious camel may attack, bite and kneel upon the brutal driver.

The working powers of the camels from Kandahar, brought in by Elder, were marvelous. Laden with 600 pounds of wool they went sixteen to seventeen miles a day, and four to five days without water, learning by experience to store up water, after practice. One carried an Afghan and the mail 350 miles in a week, while the riding camels of Mekron may run seven to eight miles per hour.

While there have been other gardens of acclimatization such as those near Cairo in Egypt described in the *Heimat* of Vienna, 1879, these are too remote from the present consideration of zoological gardens, and we turn back to the garden of acclimatization at Paris, which proved to be a veritable zoological garden, and something more.

COLLECTING WILD ANIMALS FOR ZOOS

THE ARTIST IN "BEASTS AND MEN" THUS CONCEIVES THE EFFECT UPON WILD ANIMALS OF THE COMING OF THE COLLECTOR.

This most famous of acclimatization gardens is the rival of the Jardin des Plantes in Paris, with which it has much history in common, for we find that the then director of the Jardin des Plantes, in 1854, Geoffrey St. Hilaire, in order to introduce into France, and Europe in general, new animals and plants that might prove useful, founded a society. In 1858 this developed as the *Société du Jardin d'acclimatation*, with a capital of $200,000 in shares of $250 each, which rented some fifty to sixty acres of the Bois de Boulogne from the City of Paris at an annual rental of $200.

With the aid of the city architect and

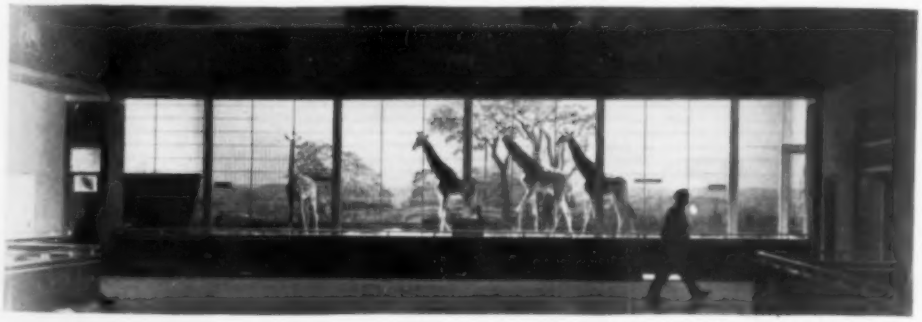
the advice of the secretary of the Zoological Society of London, the plans matured rapidly so that the garden opened in 1860 with very much the aspect of a zoological garden, large meadows alternating with woods and shrubbery, streams, pools and waterfalls with artistically laid out roads and paths.

As this garden, in a sense, took the place of the old garden of the King that the Commune had destroyed, it was thought wise to introduce into it very much not at all bearing upon the problems of domestication, and thus it developed as a large zoological garden in which, however, some of the animals had a practical use not anticipated, for when the siege of Paris was imminent, although many animals were shipped to the zoological gardens at Brussels, Antwerp and Tours as quickly as possible until the stoppage of trains put an end to this salvage, there remained in Paris some animals which were taken over by the Jardin des Plantes and the garden itself, being outside the fortifications, suffered but little. The animals, however, in the Jardin des Plantes were consumed as food and thus made useful.

After that the expatriated animals were brought back, only to suffer at the hands of insurrectionists, who made the garden a battleground and wounded both man and beast.

However, the garden of acclimatization recovered, receiving $7,000 from the society and $12,000 a year from the City of Paris for three years, and a gift of two African elephants ("Romeo and Juliet") from the king of Italy and other animals from the gardens of England, Antwerp and Brussels.

In addition to the cages and parks for the regular zoological park inmates, there are, in addition, many things that are of note. There was a project to supply pure milk at various depots in Paris; a department for the fattening of poultry; a library of natural history with lectures and conferences. Concerts, too, made the garden popular. With a fine palm-house, there was also a special building for the breeding of various species of silkworms, *Bombyx mori*, *Bombyx cynthia* and *Attacus pernyi*. Opportunities were offered the public to ride on 30 kinds of ponies from Java, Ireland, Scotland, Spain and Siam, or on horses, camels, elephants and zebras; or to be pulled about in wagons drawn by ostriches. There were: a lecture hall seating 8,000; a monkey hospital; an aquarium; a place for sale for many vegetables and plants; the most beautiful and complete collection of vines in the world; a bee house; experimental gardens; dog kennels; a hall of ninety feet displaying agricultural apparatus for sale; hunting and fishing collections;



Courtesy The National Zoological Park, 1941

GIRAFFES APPEARING AS IF IN THEIR NATIVE AFRICAN RANGE
IN THE NATIONAL ZOOLOGICAL PARK, WASHINGTON, D. C.

Courtesy of the New York Zoological Society

DEER RANGE IN THE BRONX ZOOLOGICAL PARK, NEW YORK

SHOWING THAT THE PHOTOGRAPHIC LENS TO-DAY APPLIED TO MODERN MODES OF KEEPING WILD ANIMALS MAY VIE WITH THE SKILL OF PENCIL OR BRUSH IN ARTISTIC REPRESENTATIONS OF ANIMAL LIFE.

a pheasantry; many kinds of sheep; a daily exhibition of the catching of fish by Chinese cormorants; the largest collection of kinds of pigeons ever brought together; many sorts of poultry and eggs for sale; carrier pigeons descended from those that carried 115,000 messages during the siege of Paris; a meteorological observatory; horse stables; riding school; horse breaking; a free gymnasium for children; fish hatcheries; a library of zoological and agricultural books, as well as Parisian papers and periodicals; concerts; restaurant; dogs, rabbits and all sorts of birds for sale—what else need one add to this cyclopedic Zoological Garden!

This, however, is not the whole, for there are other parts of France that aid in the general plan, and at Marseilles the extensive zoo is a sort of half-way house for animals on the way from Africa to Paris.

Although in Washington much has been done by Fairchild and others in finding and introducing foreign plants, not so much has been accomplished for animals. Consider what might have been added to our farmyards had the sailors not eaten up the Dodo—and how useful the "passenger pigeon" might have been if not exterminated. Possibly before they themselves are exterminated, men of wealth may be found to save the manatee (the mermaid of Florida waters) and the pigmy hippopotamus that might both help clear obstructed rivers and furnish both meat flesh and the inner organs some dietitians say may be so needed by man!

Zoological Gardens in India

During the centuries of progress in Europe, India had also advanced in its zoological collections, but here some of the old-day domination of princes ling-

ers on in company with the growing support of city and public zoological collections. In India we find an overlapping of the more primitive stage comparable with that of Assyria and Egypt and the more modern phase that is best expressed in the United States, where the people take the place of the prince as owners of the zoos.

In 1913, when Flower studied the collections of India, there were twelve public gardens and as many more to which the public had some access; however, these latter were chiefly private collections and special stables and places for the keeping of elephants, crocodiles, etc.

Of the twelve, three belonged to the Maharajas of Baroda, Jaipur and Mysore; five to the governments of Bangalore, Calcutta, Lahore, Rangoon and Trivandrum; and four to the cities of Bombay, Karaichi, Madras and Peshawar.

Most of them were free to all who wished to visit them, and almost all of them exhibited mammals, birds and reptiles. They were established from 1855 to 1909. The largest, at Alipore, Calcutta, founded in 1877, contained 339 mammals of 126 species, 194 species of birds and 41 species of reptiles.

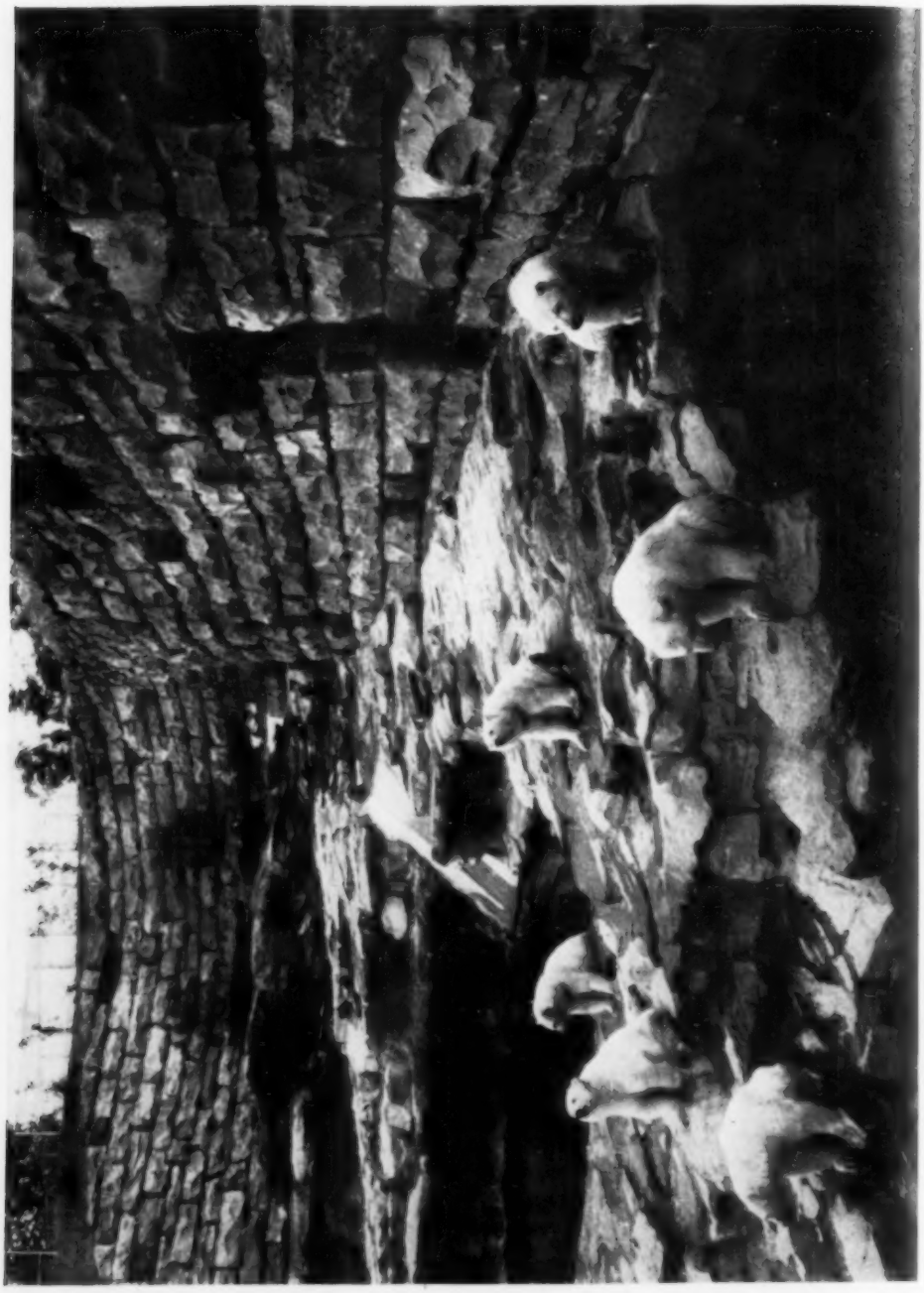
Zoological Gardens in North Asia, Africa and Australia

The modern vogue for zoological parks has left old Asia cold—great China seems not yet to have taken it up. In Japan, however, in 1900, the people started a movement to celebrate the royal wedding and raised funds which were presented to the City of Kyoto for a zoological garden to be controlled by that city. By 1923 this establishment was visited by 866,825 people, and its receipts were 10 per cent. in excess of expenses.

Africa, the great natural zoological

Courtesy of the National Zoological Park, 1941

PENGUINS BEHIND DOUBLE GLASS IN AN ARTIFICIALLY COOLED ROOM IN THE UNITED STATES NATIONAL ZOOLOGICAL PARK, WASHINGTON, D. C.



NEW BARLESS ENCLOSURE FOR POLAR BEARS IN THE PITTSBURGH ZOOLOGICAL PARK

AFRICAN AND INDIAN ELEPHANT LIVING PEACEFULLY TOGETHER
IN THE DETROIT ZOOLOGICAL PARK IN A MODERN ENCLOSURE NOT BARRED FROM THE PUBLIC; MANY PARKS SHOW "HAPPY FAMILIES" OF DIFFERENT ANIMALS LIVING TOGETHER.

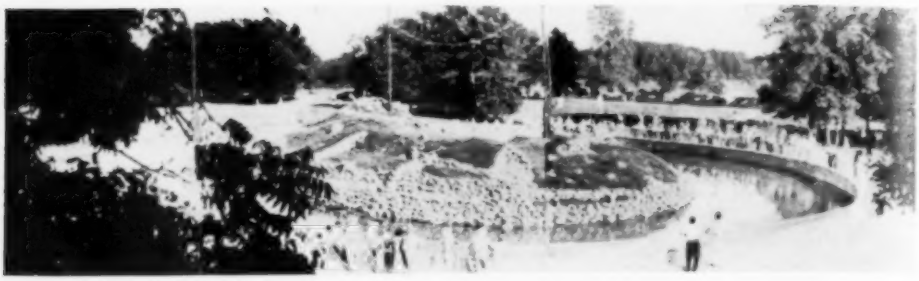
garden with its valuable reservations for safeguarding some of the native animals, is still a great supply house for menageries the world over, a center of supply being the Egyptian province of Taka, whence animals start for the important London market. In this business of supplying the menageries of the world, Germany took the lead with such men as Carl Jamrach, Hagenbach and Reiche.

The value of the animals taken in Africa becomes very much enhanced by the great costs of transportation; thus an elephant worth $20–$100 becomes, in Europe, worth $700–$1,500; a giraffe that costs $20–$50 is there worth $500–

Courtesy of the St. Louis Zoological Park, 1941

ELAND ANTELOPES IN THE ST. LOUIS ZOO
FREE IN LARGE MOATED RANGE BUT WITH AN INNER RETREAT BEHIND ARTIFICIAL BOULDERS MADE IN IMITATION OF THOSE OCCURRING NINETY MILES AWAY. HERE THE VISITOR MAY ENTER RETREAT TO SEE ELANDS INDOORS.

NEW BARLESS ENCLOSURE FOR POLAR BEARS IN THE PITTSBURGH ZOOLOGICAL PARK



MONKEY ISLANDS IN TULSA ZOOLOGICAL PARK, OKLAHOMA

180 BY 130 FEET, EMBRACED BY THIRTY FEET OF WATER. NO LONGER DO MONKEYS NEED TO BE CONFINED IN CAGES RESTRICTED BY BARS, BUT FROM AUSTRALIA TO FAR PARTS OF THE UNITED STATES THERE ARE MANY FINE BARLESS ENCLOSURES WHERE MONKEYS AND BABOONS CAN GET SUNSHINE, EXERCISE AND FREEDOM FROM HUMAN ANNOYANCES.

$700; a rhinoceros rises from $40–$100 to $1,500–$3,000; and a young lion goes up from $2–$5 to $150–$600.

But not all African animals are thus sold out of their native land; some are kept in zoological parks such as those at Giza, near Cairo, at Khartoum and at Pretoria.

Even Australia, the smallest continent and the latest to be highly civilized, has its zoological gardens; and thus, finally, carnivora gain access to this isolated land where they were so long absent that the dominant mammals, "marsupials," there took on the habits of carnivores and herbivores, as if in imitation of what was proper in the rest of the world. Australia has very much up to date zoological gardens at Melbourne, Adelaide, Sydney and Perth.

At Sydney, the bears, lions and tigers are kept in moated enclosures, and for the last there are moats eighteen feet deep and twenty-five feet wide. Maintained by the Taranga Zoological Park Trust, this park contained, in 1916, 189 mammals of 84 species, 450 birds of 103 species and 63 reptiles of 13 species.

Even New Zealand has its zoological park, at Wellington, and thus the future New Zealander can get the needed education before visiting the British Lion and seating himself upon London Bridge!

Zoological Gardens in the Americas

The long vanished menageries of the natives have been reincarnated in the many zoological gardens of all the Americas.

In South America, a fine zoological garden arose at Buenos Aires, and another at Para, Brazil; while smaller ones sprang up at Bahia and at Rio de Janeiro and at Blumenau, Brazil.

Far to the north, Canada had its zoos at Toronto, Sault Montmorency, Quebec and Winnipeg.

In the United States, the mature and relatively old city of Philadelphia started a zoo to be like that of London, and later New York had its Central Park Zoo and the great garden of the Bronx, with its remarkable rivals at St. Louis and the National Gardens in Washington. But at various times and places zoos of many grades have come into existence through the breadth, if not the length, of the land—as at Chicago, San Francisco, Cincinnati, Buffalo, Milwaukee, Prospect Park in Brooklyn, Baltimore, Denver, Detroit, New Bedford and Springfield in Massachusetts, Pittsburgh, Boston, San Diego and others.

If we now glance at a list of zoological gardens and the dates of their beginnings, we see that after the long disappearance of the menageries and zoos of

antiquity many, very many, centuries elapsed before there began in Europe, in the later Renaissance period of the sixteenth century, a serious revival of such collections of animals kept for pleasure.

With but slow increase in these gardens in the seventeenth and eighteenth centuries, there came a great increase of zoological collections all over the world, in the nineteenth century—an epidemic not yet allayed, for the end is not yet.

CHRONOLOGICAL LIST OF DATES OF FOUNDING OF SOME CHIEF MENAGERIES AND ZOOS

Sixteenth Century
1552 Ebersdorf
1554 Dresden
1570 Neugebau

Seventeenth Century
Middle San Rossore
1666 Versailles
End Cassell

Eighteenth Century
Beginning Potsdam
1716 Belvedere, Vienna
1752 Schönbrunn, Vienna
1792 Jardin des Plantes, Paris

Nineteenth Century
1812 Stuttgart
1828 Zoölogical Society, London
1830 Dublin
1835 Clifton Zoo, Bristol, England
1836 Belle Vue, Manchester, England
1838 Amsterdam
1843 Antwerp
1844 Berlin
1851 Brussels
" Ghent
1854 Marseilles
1855 Bangalore, India
1857 Madrid
" Rotterdam
" Melbourne
Before 1858 Madras
1858 Acclimatization Garden, Paris
" Frankfort
1859 Kopenhagen
" Philadelphia
" Trivandrum, India
1860 Cologne
1861 Dresden
1863 The Hague
1863 Hamburg
" Vienna
" Munich
1864 Moscow
1865 Breslau
" Stellingen, Hamburg
" Hanover
" Central Park, New York City
1866 Carlsruhe
" Buda-Pesth
1868 Mulhouse
1870 Menagerie of Chicago
" Bombay
" Blumenau, Brazil
1871 Stuttgart
1874 Basle
" Posen
" Duesseldorf
1875 Cincinnati
" Muenster
" Jaipur, India
" Alipore, Calcutta
1878 Leipzig
1879 Elberfeld, Germany
" Taronga Park, Sydney
1881 Posen
" Karaichi, India
1886 Aix-la-Chapelle
1889 National Park, Washington
1892 Mysore, India
1894 Bronx, New York
1895 Buffalo, New York
1896 Koenigsberg
1898 Pretoria, Africa

Twentieth Century
1900 Halle
" Kyoto
1902 Zurich
1904 Milwaukee
1906 Rangoon, India
1909 Peshawar, India
1929 Bern

COSTLINESS OF ZOOS

From the first collection, animals have been costly; only the very wealthy or powerful could finance their capture and upkeep. But in recent centuries they have been handed over more and more to the people as part of the educational and recreational adjuncts of civilization, not merely a luxury, but of importance as part of the apparatus for employing the spare time that seems in danger of hanging heavily on man's hands and full of potential dangers.

In the zoos, society mingles with its modern activities a bit of the observations and emotions that primitive society experienced when wandering as mere weaklings amidst the multitudinous wild things of Nature's Garden.

To stage the Garden of Eden is costly. Zoological gardens, like public schools, are costly and not of such absolute necessity that they can not be dropped in case of war, flood or other disaster, when there is necessity for the saving of sheer life.

In general, the larger number and the diversification of animals increases the whole outlay, but there may be exceptions, as in Sydney when in 1916, with only 700 animals, the expenses were $32,960 and the income only $31,625. A deficit is far too common and often it is made good by grants from the government; that is, by taxes on all the people; through gate fees—by tax on those who visit the zoo as paying visitors; and often by various side shows such as restaurants and concerts. In some zoos, as at Antwerp, there may be successful breeding of costly animals and sales that in 1903 ran the income up to $100,000 with expenses of but $24,000.

The greatest zoological garden, the London Zoo, with its 3,082 animals, had in 1923 an income of $436,970 against an outlay of $497,655.

In 1916 the great zoo of Cologne had expenses of $93,611 and only $70,000 to meet them and care for its 3,109 animals.

In 1922 Pretoria, on the other hand, took in $55,930 to care for its 1,556 animals, with expenses of but $37,260.

About that time—the next year, in fact—Kopenhagen had 1,560 animals and took in about $70,000 to meet expenses of $91,000.

And still we do not see "every beast of the field" as did old Adam!

SCIENCE IN WAR TIME

We come together at this season of the year to discuss the latest advances in our science and to listen to the announcement of new discoveries. This implies a philosophy of life, an optimistic philosophy; we would not work as individuals nor assemble as societies if we did not believe that science is worth while, and that human progress is both possible, and, for some inscrutable reason, worth working for. This was the philosophy of science in the time of the Greeks, and it is the philosophy of our science of scarce four hundred years' growth. Modern science, I need hardly say, was entirely European in its origin, as is our American scientific population; and all science is ours to promote and advance by right of inheritance no less than of intellectual sympathy.

Now that the great war is so largely arresting the progress of science in Europe it is our bounden duty to see that there is no halting in America; we should hold fast to our faith and strengthen our efforts for the advancement of science.—*Dr. Frank R. Lillie, in an address delivered before the Zoological Section of the American Association for the Advancement of Science, December 30, 1915.*

LITTLE ACADEMIES I HAVE KNOWN

By Dr. C. JUDSON HERRICK

PROFESSOR EMERITUS OF NEUROLOGY, THE UNIVERSITY OF CHICAGO

I

SINCE the days when Socrates talked and Plato wrote in the groves of Athens, and doubtless long before that, kindred minds have met and by friendly attrition sharpened the edge of keen thinking. Such debates and dialogues led to monologues if one member came to dominate the group. But how comes it that one dominates the others?

Whatever the answer, we find here the germinative stages of the academic lecture and also of modern science, the systematic search for knowledge, *scientia* as opposed to *scientiola*. Many centuries of dialectic muddling elapsed before what we now recognize as valid scientific method emerged, and even now our code is sadly defective. It too often fails us where we need it most—in the resolution of acute problems of human adjustment.

It is a mischievous tradition, widely accepted by both philosophers and men of science, that science is impersonal. It isn't. It can not be. The observations are made by persons who see what they are looking for. The working hypothesis and the experiments designed to test it are conceived in imagination, without which no science is possible, only masses of inert data. The scientific product is what it is because the people who make it are what they are.

The personal equation, then, must be recognized and taken into account in evaluating the product—quantitatively where possible, as in some astronomical observations—but it can not be eliminated from either the method of science or its product. The futile attempt to do so only puts scientific inquiry under arbitrary restraint, limiting its scope and hampering its method, as is tragically evident especially in the sciences of man in his social relations. Here the things that are really important are the personal attitudes, interests and satisfactions of the people who compose the society, the values which motivate their behavior. Science can not find the answers to the questions that most concern us—how to get along with ourselves and with one another—by ever so clever an application of a scientific method which excludes the essential factors of the problem from its formulation. And this holds for scientific investigation itself, as in every other field.

Most scientific research is properly, indeed necessarily, devoted to the accumulation of factual data and their analysis, with arduous labor and infinite pains. Any competent and adequately trained person can do this essential spade-work. But only a creative intelligence has the insight to recognize the really significant relationships among the data so brought to light. This ability is genius; it is the *Geist* which marks originality in science or any other human enterprise.

Our traditional code of scientific procedure, as a cold-blooded intellectual analysis of the raw data, was elaborated as a guiding principle for the spade-work. Here it has worked out very efficiently, and for these data rigorous quantitative statements is the ideal for which we strive. Yet even here the traditional code has missed something; its neglect of the interest and satisfactions of the worker, that is, of the values inherent in the process of research, sterilizes the product. And now when we turn to the really important work of science, the creative insight of genius, this code fails us utterly.

A million cards assembled by the Bureau of the Census are appropriately punched by intelligent enumerators. The analysis of the data recorded in accordance with any one of the standard categories established by the system of punch marks previously adopted is done rapidly and accurately by a machine. This mechanism "knows no values" and requires none. It delivers the totals analyzed according to the prearranged schedule of categories. It may tell us how many employed men there are in Detroit and what they bought with their wages. But now, if one asks the machine a question not provided for in the original design of the punch marks, he gets no answer. Our traditional scientific code, like the sorting machine, may give us objective and accurate answers if we know what questions to ask of nature; but it requires a live genius, not a dead machine, to think up really significant new questions and then find the answers. Here the sorting machine breaks down.

A de-humanized science is a dead machine which can do some routine things very well. But actual science is not dead and the great scientific discoveries have not come by close adherence to the standardized formulas of mathematical precision or logical rigor. The flash of insight which starts a genius on a long series of observations and experiments resulting perhaps in the validation of a new scientific principle doubtless has causes. And these causes are to be sought within the person of the man, not in any adventitious external happenings. No external event can give us insight. An original idea will not be generated if the makings are not already there in the conscious and unconscious organization of its inventor.

The motives which generate scientific work and sustain it, the intelligence which directs it, and the satisfactions of successful achievement are not merely the tools of science or by-products; they are integral and vital parts of it. The increasing volume of protests against the traditional dogma is a hopeful sign that the humanistic components of science are at long last receiving their due attention, as expressed, for instance, by John C. Merriam: "In the end I believe we have come to see that the scientific method is characterized in considerable measure by attitude of mind and desire for truth rather than by complete mathematical-physical solutions of questions."

This is why intimate biographies of successful men have so strong an appeal, and the autobiography is the most valuable source-book of science. For the extracurricular interests and activities of scientific men reflect their own inner natures and so give invaluable help toward a true evaluation of their work. Science is a social enterprise, "a cooperative effort toward a united understanding" (Edwin B. Wilson), and it is profitable to examine its social components as seen in association of informal groups or organized societies. This thought has led me to assemble these personal reminiscences of the Little Academies.

II

In the biography of Louis Agassiz[1] we find perhaps the most typical picture of unusual native ability directed with singleness of purpose and consummate industry toward researches in natural history of wide scope and scrupulous fidelity to detail. This child of a Swiss protestant clergyman had an understanding mother who was his teacher and who fostered his individuality, incomprehensible to her though it came to be and even though it involved the transformation of the parsonage into a veritable museum of all manner of outdoor litter and a menagerie of all kinds of wild pets.

[1] E. C. (Mrs.) Agassiz, "L. Agassiz, His Life and Correspondence," 2 vols., London, 1885.

We know of no external influences which lighted the flame of spontaneous enthusiasm for nature which led him from infancy to learn the ways of every wild thing before there was anyone to tell him even their names; to write at fourteen years of age a program of his future life which included a career in both science and literature with a long list of the books to be procured immediately, extending from Strabo in the original Greek to the latest geographical charts; to plead with his parents to allow him to go to the university instead of the business calling laid out for him; to take the medical course as lying closest to the study of nature which he had at heart; and in spite of an "invincible repugnance" to the practice of medicine to complete the medical course while ardently devoting himself to his real interests in comparative anatomy and paleontology.

While studying in Munich a group of about half a dozen students used to assemble in Agassiz's lodgings for discussion of the day's work and of things in general. The themes were taken chiefly from their own extracurricular studies of comparative anatomy and philosophy. In these sessions each of these remarkable students gave to the others a more or less formal lecture on some subject related with his own study, and the following debates often extended far into the night.

So serious and diligent were these boyish enthusiasts and so strong was their influence upon the university community that these informal meetings came to be called the "Little Academy," a university within the university. How many American students of to-day would take kindly to their daily program? From six to seven o'clock mathematics; from seven to eight breakfast prepared with their own hands; at eight a clinical lecture in medicine; at ten a lecture on mechanics; at eleven twice a week a lecture on the natural history of amphibians; from twelve to one lectures on the sense organs. Dinner was at one o'clock in a quiet private house at a cost of nine cents each. Then chemistry with experimental demonstrations, and at three lectures on entomology. On Saturday a lecture on experimental physiology and two on philosophy, or perhaps one in theology on the philosophy of inspiration. Thus the days are filled until six o'clock. Possessing but one pot, which had to be used during the day for boiling up the bones needed for their studies in comparative osteology, at evening they cleaned it out (I presume they washed it; the record is silent on this point) and cooked their simple supper. Then followed the long evening of study, discussion, or the more formal sessions of the Little Academy.

In this setting we see the workshop in which some of the great naturalists of the nineteenth century were forged. Agassiz supported himself on an income of $250.00 a year, which his father managed to save out of his own meager salary. From this he paid the university bills, bought the necessary books and kept in his employ one, and occasionally two, artists to illustrate his researches. "But they," he says, "were even poorer than I, and so we managed to get along together." Before Carlyle penned the Sartor Resartus this youth had learned his secret: "Produce! Produce! Were it but the pitifullest infinitesimal fraction of a product, produce it, in God's name! 'Tis the utmost thou hast in thee; out with it, then."

III

The Academy instituted by Plato in 387 B.C. set the pattern and inspired the ideals of succeeding learned societies up to our time. But independently of this tradition, and doubtless often in complete ignorance of it, similar associations have sprung up as if by spontaneous

generation wherever active and inquiring minds have met. Examples of this in our own time are everywhere about us. In addition to formally organized stable academies and similar associations of mature scholarship, there arise in almost every cultured community sporadic and frequently ephemeral societies generated by similar cravings for new experience and opportunities for self-culture and expression. It has been my good fortune to participate in several of these, some in college and university circles and some untrammeled by any academic traditions. Here I have found some of the richest sources of inspiration and scientific fellowship. The first of these was a formally organized college association.

On the 16th of April, 1887, my brother organized the Denison Scientific Association. I was the youngest charter member, being then a student in the preparatory department of the college. My pride in this membership is greater than in that of any of the other scientific societies with which I have been connected since that time. The association has an honorable record in the promotion of scientific work; its *Bulletin* is now in its 44th volume; and nearly all these pages record creditable scientific work by members. Perhaps the most valuable contribution to science made by this association is the intangible influence upon its membership and the college community in general. It was my privilege to attend the meeting commemorating the fiftieth anniversary of its founding, when I said:

> The key-note of the movement from its inception was, "Find it out for yourself; take nobody's word for it." The membership was composed chiefly of undergraduate students and the primary function of the organization was evidently the stimulation of interest and training in the method of science. The immediate success of the enterprise can be measured in two ways. First, by the surprising number of contributions to knowledge deemed worthy of publication made by the students themselves and by junior members of the faculty; and, second, by the reflex effect on the educational policy and actual class-room practice of the college as a whole. The significance of this second point should not escape us. It is a remarkable fact that nearly half of the student charter members came from the classical, not the scientific, course and two of the five faculty members were teachers of Latin (Chandler) and Greek (Johnson) respectively.

In an address delivered on the date of this semicentennial Professor Carey Croneis said of the twenty-seven charter members:

> They were all young, most of them in their twenties, but a great many were to attain national, and even international distinction. Of the group, thirty per cent. were later listed in "Who's Who in America." A half dozen were starred men in "American Men of Science," and two of them became members of the National Academy of Sciences. As far as can be ascertained, practically all of the twenty-seven gained some real distinction in life, interestingly enough some of them in fields quite distinct from science. . . . Herrick's influence remained strong on all of these early associates. He was the central figure in a group whose members considered themselves his disciples. . . . In a very real sense, then, Denison's little science nucleus, with C. L. Herrick as its mentor, may be compared, and favorably too, with the Agassiz or Shaler circles at Harvard, or the famed University of Kansas group under Professor Williston, the latter having been active at almost precisely the time that C. L. Herrick was at the height of his inspirational career.[2]

Some years later, when I was a junior member of the faculty of this same college, a few of us, representing as many departments of science, met every Sunday evening to talk things over, particularly what we were doing with out headpieces. It came to be customary that as each in turn led the informal talk of the evening he reported to the others what he had achieved in research, in reading or in constructive thinking since his last report. To come unprepared with some contribution was so embarrassing that this did not happen a second time. The personnel of this Little Academy shifted somewhat from year to year, but its influence was stable, and at least one of its members looks back upon the decade of

[2] Carey Croneis, *Denison University Bulletin*, 32: 133–144, 1937.

his connection with it as the seed-time of many later harvests. It is true that many of these seeds were late in germination and were quickened, perhaps by sun and rain in solitary walks of later life or in the seclusion of the study after years of patient laboratory observation and accumulation of apparently trivial details.

Not all the sessions of this academy were held within college walls or at the stated weekly meetings that our colleagues called our "Sunday School." All-day field meetings were not uncommon. The geologist would take us across-country to see a "fossil river" whose preglacial course would be followed mile after mile as a wide and winding valley now floored with fields of grain to end in some late glacial moraine which blocked the ancient channel and diverted the water to a new course.

At noon-time with weary limbs stretched on mossy cushions overlooking a narrow rocky gorge the history of the little brook below would be read backward ten thousand years, all as clearly written as if human eyes had seen it and made a record in print or on tablets of sculptured stone. An ancient rivulet captured and impounded by dams of ice or glacial moraine; a wide lake quickly filled by melting ice; the overflow through the lowest col between the rimming hills; and the slow etching of a new channel deeply incised in native rock until the lake was drained and our brook, its more strenuous task accomplished, murmurs contentedly over the pebbles in the gorge at our feet.

Trailing fossil rivers may be as thrilling sport as the hunting of the snark. You charm them with smiles and with soap; you threaten their lives with a railway share; and you march uncounted leagues in sun and frost over hills and fields and squashy swamps. And all the while the mind of the academician is projected outward alert for clues pointing the way and inward probing for forgotten experiences which, though apparently irrelevant, may tie into the present problem with some unexpected relationship.

At this time the summers were spent at Woods Hole, where a Great Academy, the spiritual and physical offspring of Agassiz's Little Academy, then, as now, brought together the most fertile scientific minds of our continent. A few years later we of the little midwestern college developed our own summer laboratory, which our students dubbed "Woods Hole Junior." Through the kindness of a neighboring farmer we secured a lease of one twentieth of an acre of pasture land—duly surveyed and recorded—which included a free flowing spring. Here a tiny laboratory building was erected over the running water and in a near-by tent one or more members of our Little Academy slept regularly for several successive summers.

The routine of the daily sessions was simple—and productive. Up at dawn. Breakfast cooked at open camp-fire outside. Then steady work at the microscope for four or five hours. At noon a ten-minute walk across the brow of the hill took me home to a hot dinner. Then correspondence and routine professional duties until late afternoon, and over the hill again with a hamper containing supplies for the next camp supper and breakfast.

Our camp was out of sight of the college or any other buildings and of any road. The seclusion was perfect. My wife entered into the spirit of the game and if, during the forenoon, telephone or other calls came for me she would reply:

"He is out of town."

"When will he be back?"

"About one o'clock."

This harmless fiction was kept up for two successive summers before town and college people saw through it, though at no time were we more than fifteen minutes' walk from the college offices.

This period marked the high-water

mark of this Little Academy. After a camp supper the long evenings were spent before an outside fire. Sometimes only one member would be in attendance. More often a colleague or two or three, with perhaps wives and children and a guest. And always a dog. Then the visitors would be escorted under the stars through the dewy pastures to their homes and soon we would be in our own blankets by the banked bonfire. At daybreak a dip in the watering trough of the pasture fed by cold spring water opened the next session of the academy.

On Saturdays during the school sessions the field meetings of the academy would occasionally be attended by visitors from the neighboring state university. The long-legged zoologist and the psychologist whose shorter legs were encased in seven-leagued boots of new moose-hide would drop down into Woods Hole Junior before the morning was old. Meantime the resident academicians had set a pot of beans a-baking.

Real camp-baked beans are a delicacy which few people nowadays can enjoy. Ordinary navy beans will do on a pinch, but the true academician will find the genuine New England yellow-eyed beans. First dig a pit about three feet deep. Line it with small field stones. Over it build a huge fire of oak, hickory or other hard wood until the pit is filled to the brim with glowing coals. Meantime the beans have been parboiled in an iron pot over an open fire, just the right proportions of salt pork, molasses and other ingredients added; over the pot lid a tin pie plate is inverted. Then with a long-handled shovel the live coals are quickly scooped out, the pot is lowered into the pit with appropriate incantations, the coals are shoveled back over it and the top covered with a few inches of dry earth. Next, walk twenty miles. At sundown the homing instinct will bring the academicians back to the bean pot. If this recipe is faithfully followed, it is guaranteed that the bean-hole will yield food fit for any immortals on Earth or Olympus—and no beans will remain in the pot at bed-time.

Those Saturday walks were exercise for mind as well as body. The curious ways of man came in for due share of attention. Sprawled in the sun on the crest of one of the denuded Welsh Hills with head pillowed on a lichen-covered stone and feet buried in ruddy sheep-sorrel, the scene would suggest a question. Upwards of a hundred years ago the first settlers penetrated this wilderness. They came direct from Wales. With hundreds of square miles of virgin land before them, all to be had for the choosing, why did they pass by the rich bottom lands and settle on these steep and rock hills? In the fertile valleys by which they are surrounded are now the richest farms in the world. On these barren slopes the hardy descendants of those hardier Welsh pioneers still wrest a meager living from the pockets of soil between the stones of their ancestral hills.

Why? Did they foresee two generations of fever and ague in the malarial thickets of the swampy bottoms and rugged health on the uplands? Did they weigh over against bounteous harvests of golden grain and golden coin in the lowlands the harvest of men, the staunchest and best our country has produced, which has since been reared on these uplands? I doubt it. The hill-man loves hills. It is bred in his bone. He does not argue about it. He does not sentimentalize about it. He lives it. And given hills with contentment, he is content.

IV

In this same period another group of naturalists began to tread the shifting sands of the Indiana Dunes at the south end of Lake Michigan. Small groups of two to six men would go out from Chicago at the week-end and spend a long day tramping the wastes of sand and forest to watch the dramatic conflict

of these natural enemies and talk of many things. The people of the group were rarely the same on two successive weeks, but a few of the men were regular attendants of these sessions of what I came to call the "Dune Academy." Among the early votaries were Whitman, Coulter, Cowles, Child, A. P. Mathews, Waldemar Koch and other distinguished members of the University of Chicago in its early years. My connection with the Dune Academy began in 1907 and continues until now. With the transformation of most of that region from the primeval wilderness of early days to clustered summer homes with paved roads and tidy lawns its charm for the true academicians has vanished; yet fortunately there still remain some secluded spots quite unspoiled for us, and occasional week-end sessions of the academy continue.

The memories of those early days when one could walk for twenty miles with scarcely a trace of human meddling are very precious. Then we would wind our devious ways from lake beach to drifting sand, through thorny scrub and noble forest, to settle down at last in mid-afternoon around a little fire, a pot of tea and a bite to eat. With pipes lighted and weary muscles at rest the talk would drift from shoe-packs to Schopenhauer, with a tinge of pessimism perhaps at both ends of the argument but never all the way between. Especially in winter, when drifting snow was piled on drifting sand, the afternoon lunch at a campfire in the lee of a sheltering dune and protected by low-hung branches of pine was always enlivened by animated discussion. Newly discovered facts were spread before us for comment and every interpretation was subject to merciless criticism. Several notable books were incubated in the warmth of these discussions.

But not all these sessions were so animated. The fact that other members of the party failed to attend never led to an adjournment, for one is a quorum of the Dune Academy and every academician has learned to get along comfortably with himself. A solitary noon camp sheltered under snow-festooned pines has featured some of the most inspiring sessions. In the troubled September of 1917 I spent four weeks in a tiny shack on the front dune looking over the Lake, alone except for an Airedale dog. In later years much writing was done in a similar cabin in the same neighborhood.

V

The next chapter in the history of Little Academies I have known takes us forward to that era when the Model-T Ford was the most popular means of locomotion in this country. The appanage of the peripatetic academy was enlarged to embrace the effective range of a flivver tramp. Camp equipment was always stowed in or around the car when we set out for no destination.

The annals of what may be called the Flivver Academy include the log of many such aimless wanderings, some by flivver, some by other means of transport, and some reaching no farther than the range of vision from study windows. For the qualifications for membership in this academy are defined in terms of mental attitude rather than by actual propinquity in space and time. These holiday adventures would take us too far afield for narration here. One incident must suffice.

We had motored up to the north end of the Iron Range in Minnesota. Here we parked the car and took to the water for change of scene and because that was the only way to go any farther in that direction. We claim to be good flivver tramps but not good fishermen. In proof of it we carried no tackle into unsurpassed fishing water and ate Alaska salmon from tins. What business, then, had we there? None whatever. But to flout the rules of logic and convention is the flivver tramp's inalienable right.

We came into the fisherman's paradise, we saw, and we did not fish. Who is the worse for it? Not the fish. And we got what we went after, a better record than some fishermen can boast.

We were in camp at Knife Falls on the international boundary, accessible only by canoe and the take-off for hundreds of square miles of more canoe-country in the hinterland. No other transport was available. At the head of the portage around the Falls is a tiny campsite. It was late afternoon. A party of four men came up, the canoes neatly balanced on the shoulders of the guides and the two fishermen carrying the duffle. One of the latter was obviously a fisherman in prospect, not in retrospect. For, item first, he wore a straw hat. Item second, while the other three men rustled up wood and supplies to make supper he sat down on a log and began to talk with me, an unknown stranger, about metaphysics.

The details of the argument I have forgotten, but the upshot of it was that the findings of Einstein have forged the last link in the chain of evidence demonstrating the truth of the idealistic philosophy.

I did not learn his name and we parted within a third of an hour. He may have been a university professor, an eminent divine or an iron-monger; he certainly was a Scot. Though you bray a Scotchman in a mortar, yet will not his metaphysics depart from him.

VI

Informal groups of earnest searchers for scientific knowledge spring up in unexpected places. Before the Great War a group of Chicago men gathered around the magnetic and lovable personality of the late George Burman Foster. They wanted to know how we lived and why, and how to do it more successfully. When Mr. Foster came and asked me to guide their discussions of the application of biological principles to problems of human experience and conduct, I said, "No. I am not a parlor lecturer and I have no ambitions in that direction." But later when he invited me to his house to meet the group socially I could not well decline. The twenty men presented a representative cross-section of Chicago's more thoughtful population—merchants, lawyers, physicians, architects, clerks, stenographers and a telephone lineman. All were busy people, some were men of large affairs, and all were alert, keen and critical.

I could not resist them. The result was that for twenty consecutive Thursday evenings, including Thanksgiving and Christmas, most of these substantial citizens sacrificed every other engagement to participate in these discussions. A systematized lecture was impossible. Within fifteen minutes the leader was bombarded with questions which cut down to the marrow of the subject, and he admits that after each three- or four-hour session he was too thoroughly exhausted and at the same time nervously tensioned to think of sleep for several hours.

There was no financial consideration involved. We all entered into the game for the joy of the sport, though in later years some of the lecturers were paid. Years passed and this group continued to hold regular meetings. The numbers increased and naturally the sessions were not so informal as at first. After Mr. Foster's death and my withdrawal, Clarence Darrow was the natural leader. His abounding energy and Irish wit, the unpredictable output of his whimsically illogical mind, his warm human sympathies and generous nature would hold the group together during the discussion of the most controversial social questions. What came to be called "Mr. Darrow's Biology Class" was known to but few people, yet its influence upon the cultural life of a great city was undoubtedly far-reaching.

A long time afterward there was an unpleasant repercussion of these conferences. One of the stories I told apparently seeped out to an adsmith for, in looking over the morning paper one day, I was disagreeably surprised to see, blazoned across the top of a full-page advertisement of a shoddy pulp magazine, my name cited as the source of the story. It was a good story—not original with me—and its unauthorized use was not legally actionable in either case. The situation resembles Kipling's version of the circumstances "when 'Omer smote 'is bloomin' lyre"—

> An' what he thought 'e might require,
> 'E went an' took—the same as me!

This advertisement appeared in many of the largest newspapers of the country and its author, if he should chance to read this, may be surprised to learn that if he had come to me and offered $10,000 for this use of my name I would have told him to go to perdition.

VII

My most recent attendance at a Little Academy was as thrilling as it was unexpected. In the course of a long pilgrimage by motor down the West Coast we paused to attend some sessions of the Stanford meeting of the American Association for the Advancement of Science. Here our largest and most influential scientific organization and the smaller satellites which revolve about it in more or less eccentric orbits presented an impressive demonstration of the social values of science in formal array. The Little Academy meeting to which I refer was the antithesis of this in every superficial aspect, and yet it approached the Platonic ideal, I venture to say, as closely as we can ever hope to attain under modern conditions.

On Sunday morning the contemplated trip to the Yosemite (which I have never seen) was abandoned to accept an invitation by Professor and Mrs. Chauncey D. Leake to lunch at their summer cabin, "Casa de los Medicos e Farmacos," near Boulder Creek and the "Big Basin" in the redwood forest of the California Coast Range. The guests were Dr. E. G. Conklin and Dr. Olof Larsell (both of whom were sometime Dr. Leake's teachers) with Mrs. Larsell and the writer.

Here during the lunch hour various others drifted in until all the members of Dr. Leake's Department of Pharmacology and their wives were present. Then to the surprise and delight of the guests we were assembled in a tiny natural amphitheatre formed by a circle of closely set redwood trees containing in the center a little open fire for warming the coffee and around this a row of benches. After enjoying Mrs. Leake's refreshments, Professor Leake opened one of his regular departmental seminars, introducing first Dr. Otto Guttentag, who gave a scholarly presentation of some German contributions to the philosophy of biology. He was followed by Dr. Charles Gurchot, a Frenchman, who, as was to be expected, subjected his German colleague's argument to pungently critical analysis. After some general discussion Dr. Conklin's extemporaneous summary of current trends in philosophical biology was a masterpiece of clarity and simplicity.

Here in the shadows of the dense redwood forest, to the accompaniment of the murmuring of a mountain brook and with passages of sharp controversial debate punctuated by vivid pencils of sunlight filtering through the lofty treetops, we found the ideal Little Academy. In an impressive natural setting whose majestic proportions favor an attitude of becoming humility and reverence this informal seminar seemed to the fortunate guests to approach perfection in spirit and method.

PHYSICS AND INVENTION

By Dr. C. F. HAGENOW
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A GENTLEMAN of my acquaintance, eminent in his profession, once asked me: "What are physics?" It was by no means an isolated instance; I have often been asked this question, though usually not in this singular (or should we say plural?) manner.

What is physics? One of our great American physicists, Henry A. Rowland, defined it as the "science above all other sciences, which deals with the foundations of the universe, with the constitution of matter from which everything in the universe is made, and with the ether of space by which alone the various portions of matter forming the universe affect each other." No doubt the chemist will object to this statement as being altogether too inclusive. It is always a matter of humorous debate whether chemistry is a branch of physics, or physics a branch of chemistry. Regarding the matter from a practical standpoint, physics can truly be said to be the basis of most engineering. A single discovery in electricity by a physicist has made possible our huge electrical industry, and everything that has to do with mechanics, heat, sound and light is at bottom a problem in physics.

Perhaps the chief reason why the question: "What is physics?" is asked more often than "What is chemistry?" or "What is zoology?" is to be found in the word itself. This goes back to Aristotle, who used the word physics to include the study of all inanimate nature. It does not lend itself to variations as familiar as "chemical" and the "zoo." The older term for physics, *viz.*, "natural philosophy," is scarcely more suggestive. The adjective form of physics is "physical," and this word, unfortunately, has a number of other meanings unconnected with the subject of physics. Physical education does not mean education in physics, nor are physical exercises experiments in physics. An amusing instance of confusing the two meanings occurs in a large and important German work on physics in which the authors interpret the statement "physical exercises for children under seven years of age" as signifying exercises in physics for these children. A physical laboratory is, therefore, no place for physical exercises!

I believe that physicists, and possibly many of my readers, are getting somewhat bored with the oft-told story of Franklin's rejoinder to the perennial question, "What is the use of this?", so often asked concerning a piece of research that has no obvious practical application. But the question seems to be exceedingly long-lived. Faraday's reply to Gladstone is very much to the point and has also been often repeated. It may not be entirely a work of supererogation to give it again as especially relevant to this article. On being asked the usual question as to the practical value of the device he was showing Gladstone, Faraday very significantly replied: "Some day you will be able to tax it."

Here is an original story the reader has probably not yet heard. A student once made this startling announcement in the course of a discussion on the attributes and comparative merits of scientists and inventors. Said he: "The inventor uses his brains, the scientist finds out things by accident." Rather hard on the poor scientist! Now it is a fact that accident does sometimes enter in; the really vicious thing about this slip-shod verdict of many people on this phase of the subject is that they utterly fail to take into account what I may call the "setting" of this event. This is another illustration of a dangerous half-truth. Just one example will make this clear. Consider the discovery of x-rays

by Röntgen in 1895. It was briefly as follows. Working with a vacuum discharge tube, covered with black paper, Röntgen found that a fluorescent screen, located at some distance from the tube, became luminous when the tube was in operation. Evidently, under the conditions of the experiment, this could not be due to visible light. Then he found that this same invisible radiation could penetrate thick books, wood and thin sheets of metal. Now consider the two elements that made this accident possible. First, Röntgen was pursuing studies on the electric discharge *in vacuo* that were begun about forty years before and had been developed by a number of investigators, notably by Lenard and Crookes. Secondly, Röntgen did not fail to take note of the new phenomenon; it might have (and probably had) escaped hundreds. There was required, then, the presence of an experienced and trained investigator. Pasteur said: "Chance favors only the prepared mind." The reader will agree that here was a truly elaborate setting for this "accident."

I must point out at once that the terms scientist and inventor are of course not mutually exclusive; many men have been eminent in both fields. But I wish to draw a distinction, for the purpose of this article, between the research worker in physics and the inventor who does not discover the physical phenomenon that he applies to his invention. It is perhaps unavoidable that the public should first become acquainted with certain physical phenomena through their successful applications in everyday life, *i.e.*, through the inventions. But it is at once surprising and disheartening to realize what misconceptions otherwise well-informed persons have concerning this relation of invention to research. Now it is quite correct to say, for example, that S. F. B. Morse invented the electric telegraph, if we mean by that that he devised a specific, practical application of a principle already known and used before him. How many know that such eminent physicists as Gauss and Weber in Germany had used an electromagnetic telegraph, though not primarily for telegraphic purposes? Their receiving instrument forms the basis of the reflecting galvanometer used in cable telegraphy. In this country Joseph Henry, also, devised an electric signalling apparatus that rang a bell through more than a mile of wire. Henry never filed a patent. In acknowledging Morse as the inventor of the telegraph, known by that name, he recorded a number of his claims, among which I shall mention only one, which many readers will recognize as the principle of the operation of the modern telegraphic sounder. Quoting Henry, "I was the first to actually magnetize a piece of iron at a distance, and to call attention to the fact of the application of my experiments to the telegraph."

Now some one may wish to interject a remark something like this: "But Gauss and Weber did not invent a practical and commercially usable device." That is true, and I may add that they were probably neither interested nor, perhaps, particularly capable of doing so. Gauss, incidentally, did request others to simplify and render more practical this apparatus. I doubt if Faraday, who discovered the principle on which our entire electrical power industry is based, could have been induced to desist from his researches to develop the essential principle of induced currents. Strange as it may seem to many a practical man, the pecuniary advantages of such an undertaking would have been among the least inducements. There have been and are such people. Pasteur, who certainly can not be accused of having contributed nothing useful to society, said to his students: "Your business, your especial business, must be to have nothing in common with those narrow minds which despise everything in science which has not immediate application." Dr. Abraham Flexner made

what may seem to many a rather harsh comment on the common notion of a great "scientist." When he asked George Eastman, who in his estimation was the most useful worker in science in the world, Mr. Eastman replied: "Marconi." Dr. Flexner surprised (and probably shocked) him by saying: "Whatever pleasure we derive from the radio or however wireless and the radio may have added to human life, Marconi's share was practically negligible." What Dr. Flexner meant, of course, was the fact that the theory of electromagnetic waves (and a bold theory it was!) was worked out by Clerk Maxwell about 1866 and brilliantly confirmed in 1887 by the epoch-making experiments of Hertz. It was then that the inventor stepped in. The wireless waves, methods of producing and detecting them (all very primitive, it is true) were there, and it remained for the ingenuity and inventive skill of Marconi and many others to develop the system of communication and broadcasting as we know it. I realize that this is stating the case in the broadest outlines only. It is scarcely necessary to add that this development involved many discoveries and elaborations concerning which one might have some difficulty in always distinguishing between the results of "pure science" and those of "invention." A curious bit of physics history is that of a discovery of Edison in the late seventies. It is still known as the "Edison effect," the explantion of which was not forthcoming for many years. It illustrates the principle of the two-electrode radio tube, or diode, often used as a rectifying detector. Adding a third electrode, the grid, a stroke of genius by Lee De Forest, gave us our modern radio tube. Now more electrodes have been added and we have the screen-grid tube, the pentode and others.

How many persons know the names of the prominent physicists among the allied nations who, during the world war, helped to solve the problem of submarine detection? As Rutherford said, it was a problem of physics, pure and simple. It was not a problem of engineering at first. The most successful detector was a modification, by our physicists, of a French device. The credit seems to belong chiefly to Langevin, in France, and to Mason in this country. There were many other contributions by American physicists. For example, a system of signalling by infra-red rays, developed by Theodore Cross; another system, using ultra-violet light, by Robert Wood. There was a leak-proof gasoline tank; a new range finder due to Michelson. A method of locating the enemy's guns by sound plotting was devised and used with great success. Remarkable improvements in aerial photography, through the agency of color filters, increased the visibility and the power of detecting camouflage. Many more of such instances could be cited.

It is to be noted that the problems just mentioned were solved by men who had no special knowledge of many of the engineering and practical features of the matters concerned. It was much more to the purpose that they had a fundamental knowledge of the principles involved and the trained minds to apply those principles. I am reminded of the remark of a friend of mine who had just been offered and had accepted a very fine position with the American Bell Telephone Company. "I do not know anything about telephones," he told me. But he knew the physics and mathematics of electricity, mechanics and sound, which was just what was wanted. There were plenty of men who knew all about the telephone as it was then used.

Poincaré remarks:

> One has only to open one's eyes to see that the triumphs of industry which have enriched so many practical men would never have seen the light if only these practical men had existed, and if they had not been preceded by disinterested fools who died poor, who never thought of the useful, and yet had a guide that was not their own caprice. . . .

No one needs to be told of the intensely

practical benefits to humanity resulting from the work of Pasteur, whose admonition to his students has already been quoted. According to Thomas Henry Huxley, Pasteur saved France a sum equal to the total war indemnity of 1870–1871. It was also Huxley who remarked:

> I weigh my words when I say that if the nation could purchase a potential Watt, or Davy, or Faraday, at the cost of a hundred thousand pounds down he would be dirt-cheap at the money. It is a mere commonplace and every-day piece of knowledge that what these men did has produced untold millions of wealth, in the narrowest economical sense of the word.

After one has learned the economic value of only a single discovery of Faraday he will agree that Huxley's estimate is far too modest.

Coming to the present, here is an evaluation of a particular research problem in actual money. Dr. William D. Coolidge, director of the research laboratory of the General Electric Company, made the following statement about a year ago, before the Temporary National Economic Committee:

> If the light used in 1938 had been provided by the lamps of 1900, with the electric power rates of 1900, the cost would have exceeded that of 1938 by over $10,000,000,000, or about $30,000,000 per day. Of course the public would get along with less light, for they could not have afforded such a lighting bill. What that would have meant in reduced safety and efficiency in industry, in reduced safety on streets and highways, and reduced comfort and convenience in the home can not be evaluated in dollars.

A good example of a very important physical phenomenon which seemed at first to have no conceivable practical use is the photoelectric effect, *viz.*, the emission of electrons from the surface of many elements when they are illuminated by light. This photoelectricity is responsible for the sound production in our talkies. This phenomenon is also the basis of the photoelectric eye and a score of other useful devices. The spread in time between discovery and its application is becoming shorter and shorter. Very recently the study of the structure of the atom by the cyclotron has led to a means of creating artificial radioactivity, which is used in hospitals when some kind of radium treatment is indicated. We are now hearing rumors of fantastic amounts of power that may be derived from the splitting of a certain uranium atom. It is safe to say that almost any discovery in physics will some time prove to be of practical use, but do not expect the experimentalist to justify his efforts by pointing it out in advance.

Sir W. H. Bragg has expressed himself on this general subject so beautifully that I am sure it is very worth while quoting him here. He says:

> It is simple and fascinating to suppose that a new invention is found as complete and clean as a nugget of gold, as unexpected and as unconnected with its surroundings, and finally as readily convertible into cash. The truth is different. Science does not increase by the constant addition of new facts to old, as a museum collection increases by the addition of new specimens. Science grows like a tree which shoots out new branches continually, and at the same time strengthens the old; twigs become boughs, and boughs become great stems, while the tree is always growing higher and higher into the light and more firmly based below. Science is like a tree also in this, that both need wise cultivation. The nourishment of the tree, its training, and its pruning, have their true counterparts in the development of science, and in both cases the fruit comes as the reward of skill and labor. This is the thing so hard to understand and yet is so important. The fruits of science are first seen when they are brought to market, and it is vaguely supposed that they have been picked up somewhere and somehow in the condition in which they appear. Perhaps they were made by the man who carries the basket. It is not realized that the fruit comes at the end of a long process, and that even a little application of science may be the result of many years of unseen growth and labor.

Sometimes the priority of the research worker is not only not acknowledged, but he is even accused of lagging behind the inventor in his knowledge of nature. The scientific man is thus represented as extremely conservative, not to say an "old fogy" and is described as being brought to grief by the more enterpris-

ing inventor. A magazine article of some years ago is a case in point. It may be of interest to give this material in some detail, as it is so typical of that kind of disparagement. The article in question had to do with Edison's work on the incandescent lamp. Here I might remark that Edison's wonderful and monumental achievement in perfecting this lamp is a good illustration of a case where the inventor merits the lion's share of the credit. The pure physics of the phenomenon of a thin filament being heated to incandescence by an electric current does not loom very large in comparison.

I shall consider only one item in this article, but it will serve to illustrate the method of the writer, who made a naïve and perfectly superfluous attempt to add to the glory of one of the greatest inventors of all time, Thomas Alva Edison. This author claimed to show that certain high authorities in electrical science did not understand the laws of divided currents. As is so often the case when quotations are used to prove a point, everything is omitted which is at all unwelcome to the writer's purpose. Here is the quotation, as given in the article in question, taken from Tyndall's essay on "The Electric Light."

> I believe I am credited with knowing something of the intricacy of the practical problem involved, and the most that I can say in answer is that I should certainly prefer to have it in his [Edison's] hands than mine.

Now as to Tyndall's own discussion of the subject, which is quite conclusive. After taking the greatest pains to explain the distribution of the current from the mains to the consumer and back again to the source (according to laws known years before) Tyndall goes on to say:

> This, if I understand aright, is Mr. Edison's proposed mode of illumination. The electric force is at hand. Metals sufficiently refractory to bear being raised to vivid incandescence are also at hand. The principles which regulate the division of the current and the development of its light and heat are perfectly well known. There is no room for discovery, in the scientific sense of the term, but there is ample room for the exercise of the mechanical ingenuity which has given us the sewing machine and so many other useful inventions. Knowing something of the intricacy of the problem, I should certainly prefer seeing it in Mr. Edison's hands to having it in mine.

As against this style of biographical writing note the following from Lucien Poincaré:

> It would be a delicate and also a rather peurile task to class men of genius in the order of merit. The merit of an inventor like Edison and that of a theorist like Clerk Maxwell have no common measure, and mankind is indebted for its great progress to the one as much as to the other.

Wilbur and Orville Wright expressed their indebtedness to Langley in the following words:

> The knowledge that the head of the most prominent scientific institution of America believed in the possibility of human flight was one of the influences that led us to undertake the preliminary investigations that precede active work. [Professor Langley was secretary of the Smithsonian Institution.] He recommended to us the books which enabled us to form sane ideas at the outset. It was a helping hand at a critical time, and we shall always be grateful.

Langley did pioneer work in theory and experiment at a time when a man was ridiculed for his pains. Langley's power-driven model flew for one and a half minutes, until the fuel was exhausted. The distance was a little over a mile. He thus established the possibility of free dynamic flight. Another machine of his, which failed spectacularly at the first trial, made a flight with a pilot after Langley's death. It is difficult to realize that in our lifetime popular derision could stop the investigations of a man of such scientific attainments as were Langley's. The reader may recall a recent statement by Lindbergh, who said that one of the important needs of aviation was research in that field.

The student of the mathematical and physical sciences has sometimes been reproached for devoting his talents and energy to purely abstract enterprises when such talents and energy could be

much better employed for more pressing and important problems, such as may be designated broadly as social problems. This phase of the subject can be best introduced by a remark by a prominent person along this very line. I do not remember the exact words, but I do remember very distinctly that he disparaged the undue attention paid to what he called cold mathematics. Now your radio waves were once only the cold mathematical equations of Maxwell. Do you remember that you once learned in your algebra course that the square of any number, positive or negative, was always positive? In the inverse operation, the square root of a positive number may be either positive or negative. So far there was no way of extracting the square of a *negative* number. Quite a while ago some one wondered what would happen if you *assumed* that you could do this also. What sort of a number would result? You know the pure mathematician has no regard for realities. So in spite of the fact that it was "impossible" to extract the square root of a negative number and get a "real" number, the operation was assumed possible and the resulting number was called an "imaginary number." This name has persisted to this day, though the number is no more imaginary when properly used than is a common fraction. Now this "imaginary" number has proved to be of the greatest importance in the thoroughly practical business of alternating current engineering. The symbol for the square root of minus one is the letter *i*, though the electrical engineer prefers *j*. The gentleman who complained of the frigidity of mathematics probably did not realize that his house lighting, and all the benefits he enjoyed from the convenience of the electrical industry, with all its social implications, were all greatly advanced by this once impossible number, the square root of minus one.

An amusing illustration of the utter incapacity of a certain book reviewer to evaluate physics as a factor in society occurred during the World War. Dr. Millikan was publishing his book "The Electron," not long after his famous researches on the isolation and exact measurement of the charge of the electron. To a certain reviewer this book, dealing with such a tiny thing as the electron, appearing at the time of a world war, seemed so incongruous that it strained his vocabulary to do justice to the occasion. It is impossible to quote him now, but he played up on the contrast, quite ludicrous to him, between the world-war violence (the crashing of worlds, as he called it) and the odd spectacle of a man being really seriously interested in such an insignificant thing as an electron. This electron, by the way, was quite a busy sort of a particle even at that time. Since then it has enlarged its scope of activity enormously. Just a few months ago, Sir William Bragg, one of England's greatest physicists, in an address as president before the Royal Society, said: "It is not universally nor even sufficiently understood how important natural knowledge has become. It is true that in a vague way the nation is brought by the happenings of war to guess at the meaning of scientific research in every kind of enterprise. But still it would be difficult for most people to grasp the significance, much less the meaning of the description of a fact like this: that the R. A. F. could not carry out its operations without the knowledge resulting from the study of cathode-rays and electrons made by our physicists, which is equivalent to saying that by this time we might well have lost the war." A rather good showing for these extremely unassuming tiny particles! For the benefit of those readers who may have forgotten the fact, these cathode-rays are themselves simply streams of electrons.

This reference to application of the knowledge of the nature and behavior of electrons is only one of many that could be cited to illustrate the need and importance of basic research in physics.

HEREDITY AND TWINS

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THE value of twins as scientific material was recognized by Francis Galton, over half a century ago. In his book "Inquiries into Human Faculty" Galton tells of sending questionnaires to twins and near relatives of twins. He received returns in regard to thirty-five pairs, described as "extremely similar," and twenty pairs of extremely dissimilar twins. The members of the similar pairs were described as having almost identical hair and eye color, and about the same stature, weight and strength. Nine incidents were recorded of one member of a pair seeing his or her reflection in a mirror, and speaking to it in the belief it was the other member of the pair. Finger abnormalities were encountered in both members of three pairs, and nine pairs showed great similarity within pairs in regard to the onset and severity of illnesses. The following story is related in regard to one pair: "A was again coming home from India, on leave; the ship did not arrive for some days after it was due; twin B had come up from his quarters to receive A, and their old mother was very nervous. One morning A rushed in saying 'O mother, how are you?' Her answer was, 'No, B, it's a bad joke. You know how anxious I am!' and it was a long time before A could persuade her he was the real man."

The twenty dissimilar pairs, although reared together, showed great dissimilarities in size, general appearance, health and disposition. No one would suspect the members of these pairs as being even related.

Since Galton's time numerous investigators have worked with twins, and scientists have come to recognize that the study of twins is one of our most valuable tools in seeking to unravel the interplay of heredity and environment in bringing about human variation. In recent years extensive twin data have been obtained by workers in Germany, Russia, England, Japan and the United States.

THE TWO TYPES OF TWINS

While of necessity circumstantial, the evidence is now convincing that identical twins and other identical multiple births consist of individuals who originated from the same fertilized egg cell or zygote. Fraternal twins arise from two different eggs fertilized by different sperms. Many years ago it was believed that identical twins arose from the fertilization of a single egg by two sperms, or "double fertilization." Our present day evidence, as we shall presently point out, gives no support to this idea.

Evidences of the two types of twins are obtained from both biological and statistical data. The occurrence of Siamese twins is analogous to the occasional appearance of double and conjoined individuals among lower forms. Direct observation of the various developmental stages is possible in many of these, and it has been shown that they invariably arise from a single fertilized ovum. Such double individuals are simply twins who have not completely separated. The nine-banded Texas armadillo almost invariably gives birth to quadruplets, always of the same sex. Studies of the embryos at various stages of development have revealed that the members of a set arise from the same zygote. This single zygote develops until about the peroid of gastrulation

before any separation occurs. At that time the embryo, which consists of a hollow sphere of cells, infolds, something like taking a hollow rubber ball and caving one side in. The embryo, at about this time, splits in two, and shortly thereafter the two daughter embryos again split, resulting in four individuals. The embryology of the armadillo is similar to that of man, and it is assumed that the formation of human identical twins occurs in much the same way. Of course, in the formation of twins, only one division occurs. If two successive divisions should occur, as in the armadillo, and one of the four daughter embryos again split, identical quintuplets would be formed. This is apparently the manner in which the Dionne quintuplets were formed. If an embryo should divide once and one of the daughter embryos divide again, identical triplets would be formed.

The human embryo is surrounded by two membranes, the amnion and the chorion. Twins of opposite sex, so far as has been recorded, are enclosed within separate chorions, and are called dichorionic. Like-sexed twins are sometimes dichorionic, and sometimes monochorionic, that is, both are enclosed in the same chorion. We should expect twins derived from the same zygote to be monochorionic, unless separation should occur after formation of the membrane. Likewise, we should expect fraternal twins to be dichorionics. Moreover, as males and females differ in their chromosomal makeup, we should expect identical twins to be like-sexed and fraternal twins to be in some cases unlike-sexed and in others like-sexed. The observations that monochorionic twins are like-sexed and that dichorionic twins are in some cases of the same sex and in others of the opposite sex are in harmony with what we might predict.

The statistical evidences are even more convincing than the biological evidence. Sex in man is determined at the time of fertilization. If the egg is fertilized by a sperm bearing the X chromosome the new individual will be a girl, whereas if it is fertilized by a sperm bearing a Y chromosome, it will be a boy. As X-bearing and Y-bearing sperms are produced in equal numbers, the chances are approximately equal that any particular child will be a boy or a girl. Thus if all twins were fraternal we should expect to obtain approximately equal numbers of like- and of unlike-sexed pairs. It is similar to the fact if we were to toss two pennies simultaneously, we should expect 2 tails one-quarter of the time, 2 heads one-quarter of the time, and a head and a tail one-half of the time. But the ratio of like-sexed to unlike-sexed twins is more nearly of the order of 2 to 1, rather than 1 to 1. The excess of like-sexed pairs in the total twin population is to be expected if a sizable percentage is identical.

The blood groups and the M and N blood reactions are inherited in a simple, clear-cut manner. As we know the exact modes of their inheritance and the frequencies of the genes involved, it is possible to calculate how frequently sib pairs should be alike in both blood reactions. As fraternal twins have the same degree of genetic similarity as brothers and sisters, we should expect them to show the same percentage of concordance within pairs in the blood reactions as exhibited by sibs. Identical twins arise from the same zygotes, the members of each pair have the same heredity, and they should therefore show concordance in the blood groups. Hundreds of pairs of twins assumed to be almost certainly identical, on the basis of general similarities, have shown concordance in blood groups without exception. On the other hand, fraternal twins should show the same degree of intra-pair variation in the blood reactions as

found among brothers and sisters. Table I shows the results of the blood tests of twins investigated at two twin conventions.

TABLE I

INTRA-PAIR COMPARISONS OF BLOOD GROUPS AND THE M AND N REACTION IN TWINS

	Assumedly Identical		Assumedly Fraternal	
	Calculated	Observed	Calculated	Observed
Alike ..	106	106	27.3	28
Unlike .	0	0	42.7	42
Total ..	106	106	70.0	70

Identical twins show concordance in the appearance of clear-cut hereditary traits, such as color-blindness, hemophilia, albinism, baldness, polydactylism and syndactylism. The evidence is thus conclusive that identical twins have the same heredity, and are of monozygotic origin. If the old belief that identical twins were the result of double-fertilization of an ovum were correct, we should expect to find some degree of intra-pair variation in identical twins in the blood groups, the M and N reaction and other hereditary traits. This does not, of course, exclude the possibility that there may be a very small percentage of twins which arises by some third process, such as the double fertilization of an ovum, but there is no positive evidence that such a thing occurs.

DIAGNOSIS

Opposite-sexed twins are obviously fraternal. Likewise, twins showing marked intra-pair differences in features, body build, pigmentation, distribution of hair over the body, and head and ear shape may readily be classified as fraternal. If none of these characteristics shows enough difference to be conclusive, blood samples may be analyzed for grouping and M and N reaction. About 62 per cent. of fraternal twins (among North American whites) will show some sort of intra-pair variation. In case the twins in question show the same blood reactions, the palm and finger-prints may be compared. If the intra-pair similarities are greater than the similarities of the two hands of either individual, the odds are about 19 to 1 that the twins are identical. Data concerning the fetal membranes at birth, that is, whether monochorionic or dichorionic, will give further evidence of zygosity. If dichorionic they are probably fraternal, and if monochorionic they are probably identical. This type of evidence is not completely conclusive, as there is good reason to believe that the separate chorions of fraternal twins may, in rare instances, fuse into one. Also, if identical twins should separate prior to the formation of the chorion, they would be dichorionic.

While it is possible, on the basis of any one of several criteria to positively recognize many twins as fraternal, there is no way to absolutely prove that the members of any particular pair are identical. We can, however, be reasonably sure that twins so similar as to be classed by relatives and friends as identical are actually derived from the same egg. This seems amply borne out by the fact that such pairs invariably have turned out to belong to the same blood groups and types. There is an occasional pair of like-sexed twins, perhaps one out of twenty pairs, where doubt may at first exist as to mode of origin. If none of the criteria we have mentioned indicates them to be fraternal, the odds are hundreds to one that they would not be so similar in all respects, unless they were derived from the same zygote.

In studies of approximately five hundred pairs of twins we have encountered five pairs concerning which serious doubt existed at first in regard to manner of origin. All were later demonstrated to be fraternal, three pairs on the basis of

intra-pair differences in the M and N reactions, one pair on the basis of great differences in the palm and finger-prints and the other pair on the basis of data revealing them to be dichorionic, and to have also had noticeable differences in hair and eye color at an earlier age.

Handedness

Left-handedness occurs more frequently in both types of twins than in the single born. About 7 per cent. of the single-born are left-handed, and close to fifteen per cent. of both types of twins. The higher percentage in both types of twins is principally accounted for by the large number of pairs composed of a right-hander and a left-hander. It was formerly believed that the high percentage of pairs showing differences in handedness was due to the fact that some pairs separated later in embryological development than did others. Those separating after the primordia determining the handedness of the individual had been established would consist of a right-hander and a left-hander, and would tend to be mirror-images of each other. They would be less similar in various respects than twins separating earlier in development, differing as do the right and left sides of a single individual. It was assumed that the high percentage of fraternal twins showing differences in handedness was partially due to too rigid a classification of identical twins, and the diagnosis of less similar identical twins as fraternal. According to that hypothesis, the less similar ones would include a high percentage of pairs comprising a right-hander and a left-hander.

Later work has shown the above hypothesis to be untenable. As pointed out above, in our own investigations doubtful cases have invariably turned out to be fraternal. Moreover, of the five cases later shown to be fraternal, three pairs consisted of a right-hander and a left-hander. There is no question but that left-handedness occurs with about the same frequency in fraternal as in identical twins. Obviously, an asymmetry mechanism or mirror-imaging can not explain the phenomenon in fraternal twins. The explanation must lie in something which both types of twins have in common, as contrasted with the single born. In all probability conditions before birth, peculiar to twins, such as crowding and position in the uterus must be responsible.

Investigations have shown that twins showing intra-pair differences in handedness are about twice as likely to have left-handers among their immediate relatives as are pairs consisting of two right-handers (Table II). This would seem to indicate that right-handed pairs are more strongly inclined towards right-handedness by hereditary make-up than are those pairs showing differences in handedness. In other words, the handedness of twins is determined both by genetic make-up and by conditions before birth. The effectiveness of conditions *in utero* in determining handedness depends to a large extent upon the genotype of the twins.

TABLE II

Correlation of Handedness of Twins with Handedness of Relatives

	Identical Twins		Fraternal Twins	
	R–R	R–L	R–R	R–L
Without left-handed relatives	105	25	84	12
With left-handed relatives	26	22	16	15
Total	131	47	100	27

The Twin Method of Research

Several scientists have made use of twins in investigations of heredity and disease. In 1936 an important investigation of tuberculosis in twins was completed by Diehl and von Verschuer of Germany. As shown in Table III, about 25 per cent. of fraternal twins and 80

TABLE III

CONCORDANCE IN INCIDENCE OF TUBERCULOSIS*

	Concordance	Number of Pairs
Identical	80 per cent.	80
Fraternal.....	25 " "	116

* Karl Diehl and O. F. v. Verschuer. Zwillingstuberkulose II. Jena, verlag von Gustav Fischer. 1936.

per cent. of identical twins showed concordance in the incidence of the disease. By concordant pairs we mean those in which both members were affected, and by discordant those pairs in which only one member showed the condition. Any discordance within identical twins can not be due to heredity, and must therefore be ascribed to environment. Fraternal twins receive, on the average, half of the same hereditary material, and their greater discordance, as compared with the identicals, is assumed to be due to hereditary differences. Let us use A to symbolize the part played by heredity, C concordant pairs, D discordant pairs, i identical and f fraternal twins. The part played by heredity in bringing about variation in fraternal twins may be estimated as follows: $A_f = \frac{C_i - C_f}{D_f}$. Accordingly, about 73 per cent. of the variations in fraternal twins in regard to the incidence of tuberculosis may be considered to be due to genetic factors. Table IV summarizes the results of various studies of concordance and discordance in twins.

TABLE IV

CONCORDANCE OF TWINS FOR SEVERAL TRAITS

	Identical		Fraternal	
	C	D	C	D
Chin dimple	27	2	15	17
Cheek dimple	18	5	15	8
Eye epicanthus	14	0	4	6
Whooping cough	96	4	63	13
Hernia	24	15	0	6
Measles	179	10	127	19
Rachitis	20	2	6	20
Cancer	29	24	13	22
Epilepsy	32	21	4	123
Schizophrenia	28	13	15	86
Crime	45	21	32	52

It is hazardous to draw sweeping conclusions regarding the relative potencies of heredity and environment on the sole basis of twin data. Twins of both types differ from the single born in having a unique prenatal environment. Position in the uterus, crowding, imbalance of the blood supply and more difficult circumstances at birth appear to play important parts in the determination of some traits.

The post-natal environment of fraternal twins reared together is more similar than that of sibs reared together. They are contemporaries, go to the same school, have the same teachers and playmates, and share more experiences. The importance of this type of environmental difference varies, depending upon the trait in question. For most physical traits and disease resistance, there is little reason to suppose it is important. It should not be overlooked, however, in the investigation of intelligence and personality traits. As fraternal twins and sibs have, on the average, the same degree of genetic similarity, differences in the degree of concordance for any traits must be due to environmental factors. Let us allow B to represent such environmental differences and s to represent sibs. Then $B_s = (C_f - C_s)/D_s$.

Unfortunately, investigations usually include only data from the two types of twins, and none concerning sibs. When sib comparisons are included, the value of the data is greatly enhanced. This is well illustrated by the data on feeblemindedness in twins and sibs, collected by Rosanoff *et al.*, shown in Table V.

TABLE V

CONCORDANCE AND DISCORDANCE IN TWINS AND PAIRED SIBS FOR MENTAL DEFICIENCY. DATA TAKEN FROM ROSANOFF*

	No. Concordant	No. Discordant	Per Cent. Concordance
Identical Twins ...	115	11	90.9
Fraternal Twins ...	128	112	46.6
Sib pairs	716	142	16.5

* A. J. Rosanoff, L. M. Handy and Isabel Rosanoff Plesset. Psychological Monographs 216, 1937, Psychological Review Company, Princeton, N. J.

The part played by heredity in bringing variation may be estimated by the following formula:

$$A_s = \frac{C_i - C_s}{D_s} - \frac{C_f - C_s}{D_s}.$$

Thus, about 54 per cent. of the variation in sibs in respect to mental deficiency may be attributed to heredity. But suppose no sib data were included. Then we should have to rely on twin data, and using the formula $A_f = (C_i - C_f)/D_f$ we should find A_f to equal 82.7 per cent. Or, suppose the data included only identical twins and sibs, then we should have to estimate the part played by heredity on the basis of $A_s = (C_i - C_s)/D_s$, which equals 90.3 per cent. In either case, the environmental forces operating to produce differences between sibs and fraternal twins can not be estimated, and the part played by genetic factors is greatly over-estimated.

The concordance-discordance method of twin research is necessarily confined to qualitative traits. It permits only two classifications, those who possess the trait, and those who do not. Variable traits, such as size and intelligence, showing quantitative variations, must be treated in a different manner. Intra-pair correlations, symbolized by r, are substituted for C and D. Thus $A_f = (r_i - r_f)/1 - r_f$, and

$$A_s = \frac{r_i - r_s}{1 - r_s} - \frac{r_f - r_s}{1 - r_s}.$$

Newman, Freeman and Holzinger recently completed an investigation of certain physical, mental and personality traits of 50 pairs of fraternal twins reared together, 50 pairs of identical twins reared together, and 19 pairs of identical twins reared apart. Table VI shows the part played by heredity in determining variation in fraternal twins in each of several traits. Comparisons of identical twins reared together with identical twins reared apart give a basis for estimating the role of post-natal environment in producing differences.

TABLE VI

THE PERCENTAGES OF VARIATION IN SEVERAL TRAITS IN FRATERNAL TWINS ESTIMATED TO BE DUE TO HEREDITY. DATA TAKEN FROM NEWMAN, FREEMAN AND HOLZINGER*

	Af		Af
Standing Height.	81	Binet I Q	68
Sitting Height ..	76	Otis Score	77
Weight	78	Otis I Q	80
Head length	78	Word meaning ...	68
Head Width	75	Arithmetic computation	72
Cephalic Index ..	75	Nature study and science	34
Finger ridges ...	90	History and literature	45
Binet Mental Age	65	Spelling	53

* Newman, Freeman and Holzinger, "Twins: A Study of Heredity and Environment," University of Chicago Press. 1937.

Table VII shows such an estimate for seven traits, as contrasted with estimates of the amount of variation in fraternal twins reared together attributable to environmental factors. It would be enlightening to know what the values of these environmental factors would be if identicals reared apart were compared with fraternals reared apart. It is quite clear, however, that the relative parts played by heredity and environment depend both upon the type of environment and on the genotype of the individual.

It should be kept in mind that fraternal twins have, on the average, half of the same heredity. If we are interested in determining how much of the variation in respect to a given trait in the general population on the average may be attributed to heredity, comparisons of both types of twins, reared apart, paired sibs reared apart, and unrelated pairs

TABLE VII

PERCENTAGES OF DIFFERENCES IN CHARACTERS DATA TAKEN FROM NEWMAN, FREEMAN AND HOLZINGER, LOC. CIT.

	Variations Due to Post-Natal Environment	Percentages of Variations in Fraternals Due to Environment
Height	24	18
Weight	87	21
Head length	19	24
Head width	58	32
Binet I Q	59	31
Otis I Q	64	16
Stanford Achievement..	87	36

reared apart should give us a fair estimate. Let us use u to symbolize unrelated pairs, and let us further assume that all of the pairs included in the following formula have been reared apart. Then

$$A_u = \frac{r_i - r_u}{1 - r_u} - \frac{r_f - r_s}{1 - r_s}.$$

Discussion

The results of various investigations of twins have emphasized the fact that the relationship between heredity and environment in the determination of variability in man is not fixed or static, but rather dynamic. That is, the relative parts played by each depend not only upon the trait under consideration, but also upon prenatal and post-natal environmental conditions and the genotype of the individual.

Most of the scientific work with twins has to date been primarily concerned with cross-section comparisons of the occurrence and degree of certain traits in twin populations. A barely touched and perhaps even more important phase of twin investigation is that of continuous studies of identical twins from birth through childhood and maturity. This should be especially enlightening in regard to growth rates, metabolism, disease resistance, intelligence and personality. The members of a pair could compare as to the effects of different diets, different types of exercises, and even different types of training in schools, on mental and physical development. It would also be feasible to compare identical twins reared together until maturity, and later to determine what changes might be brought about as a result of living in different environments and engaging in different occupations.

As identical twins have the same genotypes, any intra-pair differences must be due to either prenatal or post-natal environmental factors. Thus identical twins offer material *par excellence* for measuring the effectiveness of various types of environment and training. Fraternal twins, when compared with sibs, enable us to evaluate the unique environmental influences associated with both types of twins. Fraternal twin data, like sib data, may also enable one to determine whether or not a trait is inherited in a simple manner.

Many of the most conspicuous and interesting variations in man are undoubtedly due to a large number of genes, acting in such a variety of manners as to defy simple, clear-cut analysis. Furthermore, many such traits are conditioned to a considerable degree by environment. Especially does this seem to be true in mental and personality traits, general growth processes, vigor, longevity and disease resistance. The study of twins is the key to the solution of the relative roles of heredity and environment in the determination of variation in such traits. Twin research has only begun, and to be of greatest value it should be conducted on a much larger scale than has ever been attempted. Probably no single institution could do this alone, but many universities, hospitals, and other agencies working under a unified plan could go far in unraveling the interplay of heredity and environment in human development. This type of research would call for specialists in genetics, statistics, medicine, dermatoglyphics, psychology, blood, nutrition, endocrinology, embryology and various other related fields. Research with twins has to date been done largely by isolated workers who have been able to devote only part of their time to it. There is a definite need for some sort of a central or national association devoted to research with twins which could act as a clearing house for twin data and their interpretation. It is hoped that some such comprehensive and large-scale research with twins may be inaugurated in the not too far distant future.

PHARMACOLOGIC SHOCK TREATMENT FOR MENTAL DISEASE[1]

By Dr. EMANUEL MESSINGER

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In 1922 the medical and lay world was electrified by the announcement of Drs. Banting and Best that they had succeeded in isolating insulin, and thereby had made possible the effective treatment of diabetes. This opened an entirely new hope to sufferers from the disease, which in its severer forms had been invariably fatal. Since then, thousands of lives have been prolonged, and hundreds of thousands of people who formerly had been doomed to severe invalidism have been enabled to lead a practically normal existence. Fittingly, the discoverers of insulin were awarded the Nobel Prize in Medicine. In 1937, fifteen years later, the American medical and lay world was electrified by the announcement of Dr. Sakel that this same preparation, insulin, when used in an entirely different manner, had proved to be a remedy of hitherto unheard-of effectiveness against that most common and usually hopeless form of insanity, dementia praecox. Conservative physicians and psychiatrists greeted Dr. Sakel's pronouncement with considerable skepticism. They recalled with distaste other much publicized and ultimately discredited "cures."

And there were good reasons for this incredulous and even skeptical attitude. It had been easy for physicians to accept Dr. Banting's recommendation of insulin treatment for diabetes, since it had long been known that this disease was due to a lack of insulin production in the patient's body, and Drs. Banting and Best, after developing a practical means for the extraction of insulin from animal tissues, merely did the rational thing in satisfying this lack. In the case of dementia praecox, however—the cause was unknown—Dr. Sakel had developed his treatment simply by boldly following up a hunch, and there was no theory available which would sensibly explain its effectiveness. Dr. Sakel was not a formally trained psychiatrist, and, consequently, one wondered how authentic his original cases might have been, and how valid his determination of a "cure." His work had all been done in Europe (Vienna), and undoubtedly the criteria governing diagnoses there are more flexible than in the English-speaking countries. But, as confirmatory reports, first from England, and then from research centers in this country, continued to pour in, the skepticism began to be replaced by feelings of wonder and something of awe, as physicians began asking incredulously, with fingers crossed—Is it true that there is a new hope open for those facing the terror of being overwhelmed by the flood of madness?

For mental illness in many of its phases may well be compared to a flood. The overwhelming of a smoothly functioning mind by unusual mental and emotional strains is quite analogous to a smoothly flowing river which has become overburdened by torrential rains, and burst its banks. If the banks are high and well buttressed, composed of stout clay or rock, when the flood subsides the river will return to its usual channel. Similarly, when mental illness develops in an individual with a sound

[1] Published with the permission of the Medical Director of the Veterans Administration, who assumes no responsibility for opinions expressed or conclusions reached by the author.

heredity and previously stable personality, not undermined by any ravaging physical ills, we expect the mind's activity to return to normal rational channels when the excessive stresses and strains have passed. On the other hand, when the river's banks are low and sandy, built of crumbly materials, we are not surprised at the flood leaving behind it many permanent aberrant channels and, at times, even diverting the main stream itself to an entirely new course. Likewise, a mental breakdown developing in a shallow, brittle personality with a tainted hereditary background is more than likely to persist as a chronic form of insanity, with the streams of thought and action permanently diverted into bizarre and irrational pathways. The analogy of mind and river may be drawn still further—for instance, certain pathologic, sluggish, depressed mental states remind one of a proud stream which has dried up to a mere trickle after a prolonged period of heat and drought.

Bearing this analogy in mind, it becomes apparent that the problem of mental illness, as of flood control, may be attacked along three main lines: first, preventive—lessening the volume of emotional and mental strains to which the individual is exposed, much as the engineer builds dams at strategic points and promotes reforestation projects; second, therapeutic or reconstructive—attempting to bolster up and repair the weakened or broken banks of the personality, analogous to the piling up of levees at the weak points of the river; third, eugenic—attempting by sterilization and segregation to prevent the propagation of the mentally unfit or "fragile" personalities—a course which in the present state of knowledge is quite uncertain—which offers little solace to the current generation of sufferers and their families, and which is generally repugnant to a humanitarian society. This last measure is comparable to the abandonment as uninhabitable of otherwise desirable and fertile river bottoms, particularly in view of the fact that the aberrant personality strains which supply us with most of our insane are also known to furnish a considerable percentage of our geniuses.

Consequently, to the practising psychiatrist it is still the second line of attack which is of primary importance. He is always placed in a trying position whenever a new method of treatment of any promise is introduced and, as is invariably the case, publicized in the lay press in an over-enthusiastic, extravagant and distorted manner. This has particularly been the case in the past couple of years with the insulin and metrazol treatments for insanity. Lay writers on medical subjects have an inveterate compulsion to overemphasize successes and to gloss over or neglect to mention failures or limitations. The psychiatrist is confronted day after day by relatives of mental patients whose interest and concern has been stimulated by what they have heard or read, and in whose minds the following questions are paramount:

(1) What is meant by the insulin and metrazol treatments? What types of cases may be benefitted by these treatments, and how much benefit may be expected?

(2) What are the dangers connected with these treatments?

(3) What hope is there for the other cases?

In the following pages we shall endeavor to give an adequate and accurate answer to each of these questions. Thus, we hope to make available to the public a conservative picture of what has been and may yet be accomplished.

(1) What is meant by the Insulin and Metrazol Treatments for Insanity?

Before proceeding with the answer to this question, it is necessary that the reader have some idea of the nature of

the diseases or illnesses these treatments are supposed to benefit. Insulin treatment has been recommended primarily for certain types of dementia praecox. Metrazol treatment has yielded encouraging results in certain depressed and stuporous states.

Dementia praecox is a rather broad term used by psychiatrists to group together several more or less related forms of mental disease in which the outlook for complete recovery is more or less unfavorable. There are approximately one million hospital beds maintained in the United States. Almost one half of these (some 47 per cent.), are constantly occupied by cases of mental illness. More than half of the mental cases (probably 60 per cent.) constantly hospitalized belong to the dementia praecox group. Psychiatrists generally recognize four distinct forms of dementia praecox, which they designate as—simple, catatonic, hebephrenic and paranoid types. The characteristic symptoms of each form, briefly, are as follows:

In the simple types the outstanding symptoms are a marked lack of emotional attachment to the ordinary, so-called normal things, about which people are much concerned. There is apt to be a lack of interest in what is going on about them or in the world—a lack of affection for their near relatives or friends—utter lack of ambition or initiative. There is no real sadness, only apathy and indifference. Such patients do not read the newspapers or listen to the radios; they might be domiciled in a ward for years without bothering to learn or remember the names of any of their fellow-patients, their nurses or attendants. They show no worry or concern over illness or any other misfortune involving their family or friends. They tend to remain inert, though if urged sufficiently will usually follow the path of least resistance and occupy themselves in simple tasks. They never complain of anything bothering them, and often will permit physical illnesses to become far advanced before calling anyone else's attention to them. If some privilege or prerogative is denied them, they do not fret or fume, merely accept the denial listlessly. Nothing seems important enough for them to expend any effort to attain. They lead what is called a "vegetative" existence—eating, sleeping, excreting—and displaying little if any enthusiasm in any of these functions. The simple types of dementia praecox comprise only a very small percentage of those cases which come to a mental hospital, which is fortunate, since they do not respond favorably as a rule to the new treatments we are discussing.

The hebephrenic forms are the most numerous encountered in hospital psychiatry. These patients show characteristically the childish, silly, bizarre speech, mannerisms and behavior which popular fancy considers the hall-mark of insanity. They are apt to bear continuously a silly, insipid expression, show peculiarities of dress, often decorate themselves with all sorts of geegaws; they are often observed grimacing and talking to themselves rapidly and incoherently, and on closer observation it appears that they are responding to "imaginary" voices. It is evident that they are preoccupied with silly fantasies, and they too have lost interest in the real things which are going on about them in their daily life and in the outside world. This lack of interest becomes reflected as the disease progresses in an increasing lack of knowledge and loss of what has formerly been learned. They may exhibit delusions or false ideas of grandeur or of persecution, but express little concern about these delusions, and do not bother to elaborate any remotely logical explanation of their ideas. They often complain of bizarre bodily feelings or sensations, and may imagine they are suffering from all sorts of fantastic and

impossible physical ailments, that some or all of their vital organs are missing, diseased, or dead, or that various kinds of machines, mechanisms, animals or persons have taken residence in their bodies. Patients of this group also do not as a rule respond favorably to the new treatments.

The paranoid forms comprise the second most numerous group of dementia praecox patients. These individuals usually present a rather normal appearance to the uninitiated. They carry themselves well, are careful about their dress, clean in their habits, and generally they show a fairly well-preserved intellectual capacity. They have become, however, imbued with the idea that they are superior persons and that, consequently, others are jealous of them, and are constantly striving to degrade and take advantage of them. They manifest an air of arrogance, haughtiness or martyrdom. They feel that they are surrounded by jealous enemies who are constantly plotting against them, poisoning them, talking about them. Often they hear imaginary voices cursing, threatening, deriding them, accusing them of unspeakable thoughts and actions. They usually construct a superficially logical theory to explain why they are the objects or victims of these persecutions. Not infrequently they react violently against persons who are in the vicinity, who they imagine may be connected with their persecutors. Such cases are frequently benefitted by the new treatments.

The catatonic forms are characterized by an extremely bizarre group of symptoms. These depend largely upon what basically seems to be a blocking of thought and action, a sort of inertia which causes the patients to persist in definite forms of activity or inactivity. These include a marked tendency to definite types of stuporous states in which the patients will sit, stand or lie in fixed postures or attitudes for weeks or months on end. In these stupors their eyelids usually are closed (though an extremely rapid "nervous" flickering is common); they do not speak or respond in any way to questioning, yet it is evident that they are aware of what is going on about them. In the deeper forms of stupor they may make no effort to feed themselves or to attend to the calls of nature. Frequently, starvation may be avoided only by forced feedings with a stomach tube. Often a condition known as "waxy flexibility" is shown. Into whatever constrained or awkward position or posture they may be placed, they will tend to remain, exactly as if their bodies were made of some inert wax, instead of living nerve, muscle, and bone. Again they may show "stereotypy," repeating interminably some particular apparently meaningless movement or gesture which may have been suggested to them by others, or, more usually, is a symbolic expression of their own mental complexes. Similarly, they may repeat interminably specific words, phrases, noises or figures of speech. In contradistinction to these stuporous, automatic and passive states, they may have periods in which they are wildly excited, extremely overactive, impulsive, destructive and assaultive, and may further manifest marked tendencies to mutilate or destroy themselves. At such times they are prone to be actively hallucinated, and will rant on noisily against the "voices" they hear berating and threatening them. Strange as it seems, it is just these most dramatic and obviously abnormal types of dementia praecox, which are more apt than the others to have periods of definite normality and mental lucidity. And perhaps because of this natural tendency for "partial remission," a goodly proportion of "catatonic" patients will respond favorably to insulin and metrazol treatments.

Thus, in summing up the four basic types of dementia praecox which we have just discussed, it is clear that the psychiatrist does not anticipate favorable results from treatment when dealing with the simple and hebephrenic types, while he is much more optimistic when dealing with the paranoid and catatonic forms. A review of our original analogy of the mind and the river may clarify to some extent the reasons for this distinction. The simple type of dementia praecox may be compared to a river in which the springs of its *source* have dried up, so that an insufficient volume of current is left to sustain the former amount of industry and navigation. There is no way in which engineering can restore such a stream to enable it to assume its former functions. The hebephrenic type of dementia praecox may be compared to the river with crumbling, sandy banks all along its course. After a major disastrous flood, its originally weak walls have been washed away and broken down in so many places—so many new aberrant channels have been developed, that it is an impossible task to restore it entirely to its former course. The paranoid type of dementia praecox may be compared to a stream whose banks have only a few weak points which have been broken through. It is possible to plug these breaks and to fortify the levees sufficiently so that the normal course is restored. Finally, the catatonic type of dementia praecox may be compared to a river, which has been dammed up near its source by some natural catastrophe such as an avalanche. The original channel remains intact, and once the dam has been blasted away, the river promptly resumes its normal course. To be sure there may be an initial period of turbulent flood (the catatonic excitement), when the dam is first broken through, but after this has subsided the well-grooved channels of the personality will maintain a directed and productive flow.

At this point we must add that in very many instances, the situation is not nearly so simple as we have indicated in the above remarks. Many clinical cases of dementia praecox which we see are by no means "pure" as regards their type. They present varying admixtures of features characteristic of two or more of the types. Thus a case which is predominantly paranoid or catatonic may also manifest many hebephrenic features. Consequently, it is extremely difficult if not impossible to predict in such cases what the outcome of treatment may be. Moreover, when the illness is but newly established, the specific type is usually not well defined, and it is very common to see a case, which in its beginnings seemed to belong to the higher paranoid or catatonic categories, ultimately "regress" to the lower hebephrenic or simple forms. In fact, it is this tendency toward "regression" which many psychiatrists feel is the chief argument supporting the theory of essential unity of the disease complex called dementia praecox. It is consistent with this characteristic of the disease that all workers in the field have found that the percentage of good results in all cases treated varies inversely as the duration of the illness up to the time treatment was first instituted. In other words, the treatment to be effective must be applied before the process of regression has become marked, that is, before the disease has become crystallized in one of its lower, resistant forms. Thus, few workers are inclined to be optimistic in treating cases which have been sick over two years, and many workers feel that treatment in chronic cases is entirely futile. As a working hypothesis, however, it may be assumed that in those cases presenting mixed features, improvement may be obtained mainly in those symptoms which are not character-

istic of the regressed types of the disease.

We are now ready to describe briefly the major details of the new treatments. The treatments are strenuous and rigorous and, consequently, before they are administered every precaution must be taken to put the patients in as good physical condition as possible. In the insulin treatment, the patient is given injections on successive days of increasing doses of insulin early in the morning, before he has had anything to eat. As the proper dose is reached the patient goes through a stage of increasing drowsiness, followed by a stage of progressive loss of muscle control, followed by a stage of unconsciousness or coma. The sequence of events is quite similar to that produced by the induction of an anesthesia, as with ether. But, while an anesthetic like ether is a poison which acts by "doping" the nerve centers, insulin is a natural gland secretion which progressively diminishes the nerve center activity by removing sugar from the body tissues and nutrient fluids. Nerve activity needs this sugar since it is the only fuel which nerve cells can utilize as a source of energy; consequently, as the tissue sugar is removed the nerve-cell activity (technically called its metabolism) is progressively diminished. It has been found most advantageous to allow the insulin activity to continue for about four hours at a session. The usual course of treatment consists of fifty such sessions, administered five or six mornings a week. Thus the average course of treatment lasts about ten weeks, during which time the patient receives special nursing and dietary care. A specially trained physician must be at hand during the entire period of "coma," since he must be instantly available to take care of any untoward complications which may appear. It is this absolute requirement of extra, specially trained personnel, whose entire energies must be devoted to giving the treatments, which makes it so expensive and so difficult to incorporate in limited and curtailed mental hospital budgets. The expense of the cost of the insulin used is only a very minor item.

Each session of "coma" is terminated, that is, the patient is "awakened," by replacing the sugar which the insulin has removed from the tissues. This is done by instilling the proper amount of sugar solutions into the stomach (usually by a rubber stomach tube), or, where a more rapid "awakening" is desired, by injecting sugar solution directly into the blood stream. When the insane patient first awakens, he often shows an increased mental clarity or lucidity which may last only a few minutes. In those cases which show permanent improvement from the treatment, this "lucid interval" usually becomes progressively prolonged as the treatment is continued, until ultimately the patient is "lucid" all the time and is "insane" no longer.

About the time Dr. Sakel was reporting his first outstanding successes with the insulin treatment, a Hungarian psychiatrist, Dr. Ladislaw von Meduna, began working intensively with an entirely different type or drug, called metrazol. Dr. von Meduna felt that there was some sort of natural antagonism between the nervous disease epilepsy, and those nervous diseases grouped together under the term dementia praecox. Consequently, he felt that if one could imitate the outstanding symptom of epilepsy, the epileptic convulsion, in dementia praecox patients, one might favorably influence the course of their illness. He experimented with various drugs which were known to have convulsive effects on lower animals, and finally decided upon "metrazol," a synthetic chemical related to camphor, as the safest and most practical. He then tried out his artificially induced convulsions on humans

and his initial results were at least as spectacular as Sakel's. The von Meduna treatment consists simply of the injection into the vein, of a sufficiently large dose of metrazol to produce a generalized fit or convulsion. The convulsion is an extremely violent one, and resembles the natural epileptic convulsion in its broad outline, though not in its detailed mechanism. It is usual to give three such convulsions a week, and to give a total of ten to twenty convulsions in the average case. The convulsion itself lasts from three fourths of a minute to a minute and a half, is followed by a state of coma or complete unconsciousness lasting a few minutes, and finally by a state of confusion or befogged mental activity which may last a couple of hours. After these phases of the metrazol effect have worn off, the patient is apt to show a state of unusual mental clarity with freedom from his psychotic symptoms, very similar to the "lucid" intervals noted after emergence from insulin coma. Again, when the treatment is successful these lucid intervals become progressively prolonged until ultimately all of the picture of insanity is pushed to the background. It soon became apparent that the metrazol treatments appeared to benefit, by and large, basically the same classes of patients as the insulin treatment, with a tendency for greater success in the catatonic and stuporous groups. It also became evident that while one was likely to obtain a more rapid improvement with metrazol, the improvement was more likely to be maintained for a prolonged period when insulin was used.

Very early in the course of his experience with the insulin treatment Dr. Sakel found that a certain proportion of his patients tended to have convulsions during the course of insulin coma. He further noted that certain of these patients were prone to show a much more rapid gain in their improvement after such convulsions. As a result of these observations, he found it advisable to supplement his original insulin treatment in selected cases by artificially inducing convulsions during certain phases of insulin coma. He too chose metrazol as the most practical drug for this purpose. This "combined" insulin and metrazol treatment has also become an accepted technique with most workers in the field.

We are now ready to consider what the verdict of time and experience has been as regards these new approaches to the problem of mental disease. Three years have elapsed since these treatments were first introduced to this country, and thousands of cases have been treated during this interval. Scientifically minded physicians will discount any claims of therapeutic achievements unless they can be convinced that a sufficiently large number of cases have been treated, and that the results have been adequately checked and "controlled." By this they mean that they expect a large number of cases which have been treated by the new methods, to be compared with an *equally large number* of *similar* cases which have been treated by the old methods, and that the comparative results be evaluated after a sufficiently long period of time has elapsed. It would seem that these conditions have been met in the New York State Hospital System. Dr. Benjamin Malzberg, senior statistician of the New York State Department of Mental Hygiene, and Dr. John R. Ross, superintendent of Harlem Valley State Hospital (where Dr. Sakel inaugurated insulin treatment in this country), have recently collected and summarized the results obtained in the New York State institutions. They compared 1,039 patients treated with insulin with 1,039 patients of essentially similar characteristics who had received only the usual types of hospital treatment. They found that

almost two thirds of the insulin-treated cases showed a significant degree of improvement (65.4 per cent.), and 12.9 per cent. of the total were considered recovered. In the control group only 22.1 per cent. showed a significant degree of improvement, and only 3.5 per cent. were considered recovered. Thus, it is evident that when insulin was used a favorable outcome was obtained three times as frequently as when it was not used. These figures are further substantiated in that in a summary of 718 additional cases treated with insulin, practically the same percentages of improvement and recoveries were maintained.

As regards the results of metrazol treatment, quite a different picture is seen. Dr. H. M. Pollock, of the New York State Department of Mental Hygiene, has summarized the results of metrazol treatment on a series of 1,140 dementia praecox patients. Of this group he found that only 1.6 per cent. were considered recovered, while only 36 per cent. showed some degree of improvement. These statistics when compared with those given for the control group would seem to indicate that on the whole metrazol treatment is definitely not worth while. Practically everyone who has worked intensively in this field, however, has encountered certain cases which responded only indifferently to treatment with insulin alone, yet showed a spectacular improvement when metrazol was used in addition. Perhaps the metrazol figures suffer by comparison simply because the great preponderance of cases treated were not of the catatonic, stuporous types which are most amenable to the convulsive method. Another, more potent argument against the indiscriminate employment of metrazol is the rather frequent occurrence of serious physical complications which we will mention below. In passing, we might mention that in recent months exceptionally favorable results have been obtained with the use of metrazol in certain chronic depressed mental states, not belonging to the dementia praecox group of illnesses. It may well be that ultimately metrazol treatment will find its chief sphere of usefulness in such new fields.

(2) What are the dangers and possible untoward reactions which may be associated with these treatments? In describing the insulin method, it will be recalled, we compared the development of insulin coma to the phases of administration of an anesthetic. If we bear this in mind, we can readily understand how the dangers of insulin coma are comparable to those of a period of deep anesthesia. Most of us can remember how with years of experience and refinements of technique the dangers and, consequently, the dread of anesthesia have been progressively diminished. Similarly, with insulin coma, as our experience has widened and our procedures have become perfected the dangers have lessened and our fears have diminished. Now, in any state of unconsciousness or coma the possibility exists that the patient may aspirate (or inhale) fluids or secretions from the mouth or upper air passages into the lungs, and such aspirations are likely to lead to a severe inflammatory condition or "pneumonia." In the old days when the methods of administering anesthesia were still rather crude, such "ether pneumonias" were rather common. Nowadays, these complications are so rare that the term "ether pneumonia" is practically obsolete. Likewise, in the earlier days of insulin-shock treatment "aspiration pneumonias" were fairly common, while lately as techniques have become progressively refined and workers have become more expert, the incidence of this complication has markedly diminished. Another serious, but fortunately, rare complication which may be

encountered is that called "prolonged" or "irreversible" coma. In this condition, the patients fail to awaken as they should, soon after the usual means of restoring the blood-sugar level have been employed. Recent studies by Dr. J. Wortis and R. H. Lambert from the Phipps Psychiatric Clinic of the Johns Hopkins Hospital, have indicated the causative factors for most of these mishaps, and have indicated satisfactory measures for preventing and treating them.

A concrete idea of the actual mortality risk associated with the insulin-shock treatments may now be secured by reviewing Dr. Malzberg's statistics from the New York State Hospital Service. In 1,039 patients who received insulin treatment there were thirteen deaths. On the other hand, in the control untreated group of an equal number of comparable patients, there were forty-eight deaths. From these figures it would seem that patients selected for the insulin treatment had more than three times as good a chance to survive the first few years of their mental illness as their less favored companions. While it is appreciated that the insulin-treated cases constitute a physically select group, it must also be borne in mind that when insanity is permitted to run its natural course unmolested, it frequently leads to inroads in the physical health of the patients and consequently reduces their resistance to bodily illnesses and infections. On the other hand, when insulin treatment has been used the patients have invariably gained much weight and have shown considerable improvement in their physical status, even in those cases where no worth while restoration of mental function has been obtained.

With metrazol treatment we must reckon with a considerably higher proportion of hazards and untoward reactions, even though the general mortality rate is not significantly higher than in the case of insulin. From the humanitarian standpoint, metrazol treatment is decidedly inferior since many patients find it exceedingly unpleasant and in many cases overwhelmingly terrifying. For the most part, however, these feelings of terror may be obviated by using the combined metrazol and insulin method. More important is the occurrence in occasional cases of fractures and dislocations of certain long bones of the extremities. These complications are the result of the uncontrolled violence of the metrazol convulsion, a factor which can hardly be eliminated since it is generally agreed that it is the convulsion itself which produces the desired curative result. There have also been a few isolated instances reported of sudden death following a metrazol convulsion due to paralysis of breathing or heart failure. Such fatalities also seem unavoidable, since any form of generalized convulsion (of the epileptic or other natural types), entails the same possibility. A more hopeful outlook has developed as regards the "pneumonias" and "lung abscesses" which have been known to complicate occasional cases undergoing metrazol treatment. Dr. M. Zeifert, of the Brooklyn State Hospital, has recently demonstrated that this type of complication is generally caused by the injection of the drug introducing minute blood clots into the circulation, and he has devised a simple, effective method of preventing this. Finally, it has been found that a certain proportion of metrazol-treated cases may show minor evidences of damage to the bony elements of the spinal column, as disclosed by x-ray studies. While for the most part these spinal column changes do not seem to cause clinical symptoms, these findings have naturally led to increased caution and conservatism in the use of metrazol. Means are now being

developed which will probably prevent these changes in the future. In the meantime, in view of this list of complications it would seem the part of wisdom to employ metrazol only in those cases which seem to offer a reasonable prospect of improvement.

(3) In conclusion, what hopes can we hold out for the chronic cases of dementia praecox—those which we have found are to a great extent not amenable to these new forms of treatment? As regards recent cases, it is clear that we can readily agree with Dr. Malzberg, who wrote ". . . it appears permissible to draw comfort and encouragement from the present results. No longer need families feel the anguish and despair that come from the thought of an incurably stricken relative. It is necessary, however, to reiterate the pressing need of early diagnosis and treatment, and this requires the intelligent cooperation of the public with hospital authorities . . ." It is equally clear that we have only begun to scratch the surface of the problem of these forms of insanity. What further research and experiment along these lines will uncover, it is impossible to predict. Certainly, since these initial steps have been taken, we can anticipate an accelerated rate of progress. Even in our most advanced chronic cases we are now accustomed to see interludes of mental clarity when they are under the influence of insulin and metrazol. Does not this indicate that we are dealing with a correctible disorganization of function and not an irremedial destruction or alteration of structure? We have become reoriented to the problem. From an attitude of hopeless fatalism we have been converted to one of optimistic resourcefulness. With this change of attitude it seems inevitable that more and more effective tools will be devised to return the wayward mind to its normal track.

EDUCATION

WESTERN civilization has for more than two thousand years sought to establish a rigid separation between reason and emotion, between "objectivity" and "values." The material fruitfulness of the separation in the past is the chief reason for its uncritical acceptance in the present. The intellect, however, is not simply an aspect of human life—and a superior aspect in typical Aristotelian tradition—but it arises out of the emotional and ethical life, is deeply rooted in it, and draws its strength and stamina from it. The moral and emotional bleakness of typical intellectual communities, and many of the characteristic problems of the American college and university can only be understood in the light of the persistence of this tradition. When we discuss our "problems of teaching" and set large staffs at work on the problems of "youth" and "teacher's training," we are simply tracing some of the symptoms of a malady that is rooted in this distinction of reason and emotion that underlies most of our thought about the entire educational process. . . .

Occasionally, a teacher in the humanities or the social sciences will venture the statement that the "relations" of subjects or the "meaning" of the learning is the heart of good teaching, but beyond that point few will risk themselves lest they be accused of "preaching." So —in the language of the Sermon on the Mount—while the young clamor for bread, we continue to offer them stones, and of the discontent of the young provokes critical discussion, it is limited to the quality of the stones and to methods of improving methods of manufacturing more excellent stones. . . . The first need is therefore a complete shift of focus. What has partly developed as an unplanned by-product must now be seen as clearly within the general responsibility of the educator. Talent and funds formerly restricted to academic purposes in the narrow sense of the term must now be shifted from sheer cultivation of intellectual virtues to education for the *whole* man, for men as knowers and doers and appreciators. . . .

If we in the schools do not live up to our other-than-intellectual responsibility, if we do not reach into moral and emotional fields in a manner that is justifiable from the standpoint of the values of a free society, *someone else will*. For the need exists, and the trend is toward intensification of the pressures that have brought it about. Thus, in a real sense, the survival of a free society may be determined by the flexibility with which we think of the limits of formal education in a changing world.—*Inaugural Address of Harry D. Gideonse as president of Brooklyn College.*

THE MATERIAL BASIS OF EVOLUTION[1]

By Dr. SEWALL WRIGHT
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THEORIES of evolution may be classified according to the demands which they make on chance variation. No demands are made by a group of theories under which evolution is a byproduct of individual physiology, whether directed by environmental influences or by the inheritance of individual adaptations or by an innate developmental process (orthogenesis). Theories of this group have had a wide appeal but have been largely discredited by the results of experiment. Under a second group of theories, evolution is a population matter, with varying emphasis on the pressures of recurrent mutation, of selection among individuals and of the effects of inbreeding, crossbreeding and intergroup selection in the hierarchy of partially isolated subdivisions of the species. Finally come the theories under which unique mutations are the crucial events, with subdivision according to whether such mutations are supposed to give rise merely to species, the higher categories arising by a cumulative process, or whether the higher categories as well as the species are supposed to appear abruptly. Dr. Goldschmidt has been the leader in recent years in advocating this last viewpoint on genetic grounds. He has now assembled pertinent data and his deductions from these, in book form,[1] an elaboration of the Silliman Lectures which he delivered at Yale in December, 1939.

The book is not intended to cover the entire field of evolution. It is an "inquiry into the types of hereditary differences which might possibly be used in evolution to produce the great differences between groups." There are two main parts—"Microevolution" (pp. 8–183) and "Macroevolution" (pp. 184–395)—in accordance with the absolute distinction which Goldschmidt has come to make between evolution within species and the origin of species and higher categories. He reaches the following conclusions with respect to microevolution.

> Microevolution within the species proceeds by the accumulation of micromutations and occupation of available ecological niches by the preadapted mutants. Microevolution, especially geographic variation, adapts the species to the different conditions existing in the available range of distribution. Microevolution does not lead beyond the confines of the species and the typical products of microevolution, the geographical races, are not incipient species. There is no such category as incipient species.

The reasons given for concluding that the processes which determine microevolution have nothing to do with macroevolution may be summarized briefly as follows: the observed discontinuity of species and higher categories can not be explained by these processes without postulating an unreasonable amount of extinction of intermediates; these processes are too slow; they are too limited in scope, since it is inconceivable that mutations of protozoan genes could furnish enough material for the evolution of higher animals, even granting duplication; and finally gene mutations are inadequate in kind. "The germ plasm as a whole controls a definite reaction system controlled as a whole by one agency."

As hereditary cytoplasmic differentiation is ruled out as an important factor, the author concludes that only one possibility is left.

[1] *The Material Basis of Evolution.* R. Goldschmidt. Illustrated. v + 436 pp. $5.00. May, 1940. Yale University Press.

Species and the higher categories originate in single macroevolutionary steps as completely new genetic systems. The genetical process which is involved consists of a repatterning of the chromosomes which results in a new genetic system. The theory of the genes and of the accumulation of micromutants by selection has to be ruled out of this picture. This new genetic system, which may evolve by successive steps of repatterning until a threshold for changed action is reached, produces a change in development which is termed a systemic mutation. Thus selection is at once provided with the material needed for quick macroevolution.

Goldschmidt holds that this theory avoids the insurmountable difficulties which he finds at all points in "neo-Darwinism." As the reviewer is listed among the advocates of neo-Darwinism it may be inferred that he does not find himself in agreement at all points. A detailed critique is not practicable in the scope of this review, but certain general points may be noted.

The antithesis between Goldschmidt's viewpoint and neo-Darwinism is not simply one of preference for systemic chromosomal changes as opposed to micromutations. The neo-Darwinists have not been concerned primarily with the problem which is central in the present book, the types of mutation involved in evolution. Their primary concern is the dynamics of the process, accepting all types of mutation actually observed. As the formal laws of heredity are the same, to a considerable extent, for gene mutations and the simpler chromosomal changes, the same theory applies to both, with minor complications, and has been so applied. Goldschmidt gives no serious discussion of questions of dynamics, and conclusions from statistical genetics are in several cases seriously misinterpreted. Yet the dynamics of the postulated accumulation of subliminal steps in chromosome repatterning and of the establishment of the systemic mutations, once the threshold has been passed, are questions which must be considered, if valid comparisons are to be made with the conclusions reached by neo-Darwinism.

From the latter viewpoint, the species (in sexually reproducing organisms) has a complex reticular structure in time, made up on a fine scale of the conjugating and segregating lineages, and, on coarser scales, of local populations and of subspecies. These groups tend to drift apart under a process that has jointly adaptive and fortuitous aspects (selection in relation to local conditions and effects of inbreeding). They can seldom get very far apart, however, and are continually shifting in character as long as continuity is maintained by cross-breeding. The species as a whole gradually changes its character as a result of intra- and inter-group selection and, under certain conditions, of accidents of sampling. If isolation of any portion of the species becomes sufficiently complete, the continuity of the fabric is broken. The two populations may differ little if any at the time of separation but will drift ever farther apart, each carrying its subspecies with it. The accumulation of genic, chromosomal and cytoplasmic differences tends to lead in the course of ages to intersterility or hybrid sterility, making irrevocable the initial merely geographic or ecologic isolation.

There are certain similarities with results to be expected from Goldschmidt's systemic mutations: subspecies are *not* ordinarily incipient species and there is usually marked discontinuity between species, occurring without any necessary extinction of contemporary intermediates. Under neo-Darwinism, however, these are relative matters, while absolute under Goldschmidt's scheme.

Goldschmidt devotes much space to the "bridgeless gap" between species which is crucial for his theory. To the reviewer, it appears that the data indicate every conceivable intergrade in degrees of morphological and physiological distinction, of chromosomal differentiation and of cross-sterility or hybrid sterility, with the correlation between these criteria far from perfect. Goldschmidt

recognizes the lack of perfect correlation. He holds that "the development of intersterility is therefore to be regarded as the decisive step in the isolation of species." This then is the most essential effect of the systemic mutation. He devotes considerable space to the troublesome cases that have been turning up in increasing numbers in which sharply distinct, non-interbreeding populations living in the same region (and thus apparently good species) have been shown to be connected around a circle by a chain of intergrading types (making them merely subspecies). Goldschmidt, taking the latter horn of the dilemma, decides that the criterion for a good species is demonstrated physiologic intersterility or hybrid sterility, in contrast with failure to interbreed which may be due merely to psychologic causes. Thus he unites into one Rassenkreis two species of deer mice, *Peromyscus leucopus* and *P. gossypinus,* which hybridize rarely if ever in nature, where their ranges overlap, but which have been shown by Dice and Blossom to produce fertile hybrids in the laboratory. He does not, however, refer to the existence of fertile hybrids from crosses between bison and cattle and between pigeons and doves which would relegate accepted genera and families to the level of subspecies by this criterion. Later in the book indeed he recognizes that "good" species (of lepidoptera) may produce fertile hybrids. The question of an absolute difference in kind between the products of microevolution and of macroevolution thus seems to be left in a rather unsatisfactory state. It may be added that he himself to some extent cuts the ground from under the conception of a "bridgeless gap" by suggesting later that genes have no existence except as undefinable regions in the chromosome pattern, that gene mutations are merely highly localized changes in pattern and thus that there is no essential difference in kind between the materials of microevolution and those of macroevolution. Moreover, the hypothesis that repatterning may require many steps before a systemic mutation occurs, tacitly reintroduces "incipient species" though not necessarily in the same sense as the recognized subspecies.

With respect to the alleged slowness of neo-Darwinian evolution it may be said that the theoretical rate depends very much on the conditions. Under reasonably stable conditions, with every ecologic niche occupied, theory indicates equilibrium of all gene frequencies to a first order in spite of continual mutation, considerable variability if the population is large, and severe selection. Nevertheless, second-order processes, in a species with a hierarchy of partially isolated subgroups, permit continuous, if usually rather slow, change. There is always the possibility, moreover, that this may lead to an adaptation of a type that is of general significance, perhaps opening up a new way of life. The result of such an adaptation would be a relaxation of selection, a rise in the frequencies of many mutant genes and great increase in variability and in numbers. With ecologic isolation in the various niches now open to the species, and selection pressures now directed differently in each niche, an explosive evolutionary process is to be expected, an adaptive radiation within a new higher category. The same process may occur from a change of conditions. It would seem inevitable if a species reaches an unoccupied region that offers diverse opportunities. Such events must have been relatively common early in geologic time. A relatively recent example seems to be found in the history of the Drepanids of the Hawaiian Islands (an endemic family of birds with 18 highly diversified genera and 40 species, presumably tracing to a pair or flock of stray migrants of an American species) yet Goldschmidt cites this as unimaginable except by an outburst of

systemic mutations of family, generic and specific rank.

It will be well to reiterate that neo-Darwinism is not concerned solely with micromutations. It is quite in accordance with the theory that mutations with conspicuous effects may play an important rôle in the adaptive radiation of populations for which selection is relaxed, provided they do not have deleterious effects on individual physiology or fertility. On the other hand, complex adaptations would be enormously more likely to be reached by a cumulative process, involving trial and error, than by a single step as postulated by Goldschmidt. To the reviewer, the latter's theory seems to make demands on chance that are much too severe, both with respect to the origin of the complex differences between species and their establishment, recalling the postulated abrupt occurrence of intersterility with the parent stock.

The origin of new types by polyploidy is a process in which the individual mutant is the crucial event, which must be recognized by neo-Darwinists as of considerable importance. In these cases, however, there is either little initial change in character (autopolyploidy) or there is a balance of parental character after hybridization (allopolyploidy) favorable to survival. There is a population problem even here, in that the low fertility of triploid hybrids with the parent stock raises severe obstacles to establishment unless vegetative multiplication occurs freely. Goldschmidt himself considers autopolyploidy as falling within the scope of microevolution and does not ascribe primary evolutionary significance to allopolyploidy.

With respect to limitations in the amount of material for evolution provided by gene mutation as compared with chromosome repatterning, it is not clear that the possible combinations of all possible mutations at thousands of loci furnish less material than the possible permutations resulting from repatterning of normal chromosomes. The evidence at present suggests that the material at each locus (which may be thousands of times as much as that in a large protein molecule) may be capable of mutating through an indefinitely extended, branching series of alleles. Every locus may thus have had an exceedingly complex evolutionary history from protozoan to man.

At the root of the differences between Goldschmidt's viewpoint and that of neo-Darwinism seem to be different conceptions of the physiological relations between germ plasm and organism The earlier evolutionists, under the influence of a rigid conception of morphological homology, were seriously troubled by the apparent necessity for assuming independent heredities for each part of each replicated structure. An enormous load was lifted when it was recognized that complex differences in form may trace to simple differences in the developmental process and that the same genetic system that determines, through physiological channels, the form of one structure may be expected to give the basis for more or less similar replications wherever the local conditions are sufficiently similar. Goldschmidt has played a leading rôle in bringing home to geneticists the necessity for a physiological interpretation. This general viewpoint is explicitly accepted by all those whom he lists as neo-Darwinists. Goldschmidt, however, seems to hold that the conception of the organism as an integrated reaction system requires a corresponding *spatial* integration of the germ plasm and that essential change in the reaction system can thus come about only by repatterning of the chromosomes. To others, a *temporal* integration is all that is necessary, or even possible, with the chain reaction as the simplified model. Within the organism as a more

or less integrated reaction system, there is a hierarchy of subordinate reaction systems, each with considerable independence, as shown by capacities for self-differentiation. Thus there must be partially isolated reaction systems for each kind of organ and for each kind of cell. It is difficult to see how any spatial pattern in the germ plasm can operate in determining these, but there is no theoretic difficulty with a branching hierarchic system of chain reactions in which genes are brought into effective action whenever presented with the proper substrates, irrespective of their locations in the cells. There is no limit to the number of reaction systems that can be based on the same set of genes, and such systems may obviously evolve more or less independently of each other.

In an introductory chapter, Goldschmidt cites about a score of characters whose evolution he challenges the neo-Darwinist to explain. The actual course of events has usually been so tortuous in cases in which the evidence is reasonably complete that no attempt at reconstruction without direct evidence can be taken very seriously. However, there appear to be no special theoretic difficulties in the cases cited if the neo-Darwinian position is correctly understood. We can only take space for one of these cases but it is typical of several. Goldschmidt holds that alternation of generations could only have arisen by a systemic mutation. Let us consider the case in coelenterates, beginning for sake of argument with a hydra-like polyp, multiplying by budding. Colony formation could arise gradually by the accumulation of micromutations, causing delay in separation of daughter polyps. Differentiation of polyps into nutritive and reproductive zooids involves the same sort of problem as the differentiation of organs within an individual. Alternative reaction systems may become differentiated gradually with expression related to position in the colony. The reaction system of the reproductive zooid may become modified gradually to provide for increasingly regular separation from the colony and for locomotion, until the medusa type is reached. This, incidentally, offers a new way of life and evolution may continue by gradual suppression of the reaction system of the fixed phase and elaboration of that of the free phase.

So far we have compared Goldschmidt's theory with neo-Darwinism largely on the plausibilities with which they explain evolutionary phenomena. But neo-Darwinism takes its premises from the chromosome theory as actually developed by genetics and cytology. Goldschmidt deduces a different type of chromosomal organization, on the basis of the supposed theoretic necessity of his systemic mutations. No data are given that support the conception of a spatial pattern of the germ plasm, correlated with the reaction system of the organism. Against this is the independence of the chromosomes and the apparent absence of any correlation between location of genes and at least the more conspicuous effects of their mutations. Abundant data indicate that a type gene produces its characteristic effect in translocations whether the translocated piece is small or large, or if large whether the locus is near the right end or the left end or the middle. The effect may be weakened or less stable or otherwise modified, but the type alleles of white, of yellow, of *cubitus interruptus*, etc., of *Drosophila melanogaster* still retain their essential specificities. The simplest description of the genetic data is still obtained by attributing specificity, independent of position, to each gene and merely qualifying this by recognition of occasional second order effects of position. The old question whether adjacent genes are completely separate or are merely specialized regions in a continuum is irrelevant in this connection.

Goldschmidt's contention that char-

acter differences comparable to those between species can not be brought about without repatterning is refuted by the characters of trisomics in Oenothera, Datura, Nicotiana, etc. In these there is no repatterning of any chromosome but merely quantitative increase in all genes of one chromosome, yet the morphological and physiological effects give the appearance of specific difference. On the other hand, a single moderately long inversion should annihilate the pattern of a chromosome as a whole. Yet inversions either have no effect or effects no greater than single gene mutations. The hypothesis that there is a threshold in repatterning at which the systemic mutation makes its appearance seems to be of a wholly *ad hoc* character.

While the reviewer radically disagrees with the author's central thesis, he wishes to testify to the importance of the book. A great store of well-selected data have been assembled from diverse sources, fairly presented and discussed from viewpoints which must be carefully considered by any one interested in the problem of evolution.

THE BIOLOGICAL BASIS OF VALUE

By NINA BULL

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SINCE the dream of a world made safe for democracy has not come true, and the various unrelated kinds of value that civilized humanity has set such store on are in danger of being swept away, it is high time to consider certain basic values, and their corresponding needs which are forever motivating living creatures, from the lowest to the highest. These basic values all have to do with the conservation of life itself, and can be summed up in a rather general way under the familiar concept of *self-preservation.*

In this concept, however, we need to understand a great deal more than the obvious fact of a strong, persistent compulsion to save one's own skin under the great majority of circumstances. Just as self-preservation in every individual cell within the body takes on a generic form which causes activities concerned with preservation of the organ to which it belongs, and also of the body as a whole, so a single human individual becomes automatically concerned about the preservation of his family, his friends, his group, his country, and even, at times, about the entire human race; so that any threat to these is registered as *danger.*

The gravest of all dangers to the race is its extinction, and this is avoided by the sexual instinct, which serves the larger end of race or species conservation, although it works through immediate individual needs of pleasure and relief. Goethe has called it nature's trap to lure the individual into the act of reproduction—to keep the race alive. It is essentially a contribution to survival.

Such an elastic concept of self-preservation, which allows for every kind of preservation of the group as well as of the individual, provides a basic principle of motivation, and a biological foundation for the sense of value in itself. And this is true whether the value is positive or negative in character—that is to say, associated with something that produces benefit on the one hand, or something that produces injury on the other. Ideas of "good" grow out of our experience of benefit, and ideas of "evil" out of harm. In the last analysis, all values simmer down to this essential pair, no matter what we call them.

These positive and negative aspects of value can be looked at in various ways. For example, there are two phases of self-preservation in the individual which correspond respectively to the peace and war activities of nations. Peace-time activities, individual as well as national, build for the future—they store supplies, put money in the bank, build up reserves of every kind "against a rainy day." Also, they educate, re-educate, invent, explore, investigate, "create" and play. And special ways of doing all these things determine "cultural" values, in an individual or in a people. Then comes emergency, and all resources and reserves have to be called upon. Perhaps the enemy is actually bearing down on us, and mobilization in the literal sense of the word is demanded. Or, perhaps the educative and investigative process results in enough wisdom to foresee and avert catastrophe, without recourse to "arms."

None of the peace-time values can be correctly estimated, however, unless their contribution to survival is appreciated, and also the special way or ways in which this contribution is made. It is the preparational character that makes them seem important (which is what we mean by *interesting*) even in play, where the individual is living in the present and never thinking of any such connection. The kitten does not know why it is so excited by the falling leaves, and wants to play at catching them. It does not recognize this play as an unconscious kind of education in agility. Most of the play of human beings contains some element of such comparatively painless education, and people struggle with their scores, their form, their rivals, to overcome their own imperfections in this or that direction, and train new faculties, agilities, discriminations, modes of cooperation and the like. The "fun" of play is a device—another one of nature's traps—to lure the individual into preparational activities for exigencies bound to come. All this is quite apart, of course, from its more immediate recreation value, which contributes to survival in a very different way, counteracting as it does the danger of too much tension.

The two great fundamental values, biologically speaking, are danger and security, and endlessly the instinct of self-preservation concerns itself with both of them—avoiding, coping with, warding off or forestalling some danger on the one hand; and working for, or struggling for, or guarding some security on the other. When these two primitive and fundamental aspects of the instinct of self-preservation are lost sight of *in their relation to each other*, we have the various phenomena of decadence and drifting—where pleasures and skills are continually sought as if ends in themselves, that is to say, without awareness of any biological significance—survival value—attached to them. This vagueness as to the *meaning* of activities is one of the chief causes for the confusion of values that meets us everywhere to-day. It keeps the modern individual uneducated and undeveloped in the all-important region of self-knowledge, through dwelling on secondary reasons for his own behavior because he has no understanding of what is primary in motivation.

The fact that life is threatened from so many different sources, some of them remote in time or space, calling for correspondingly different ways of coping, or escaping, or adjusting, has blinded us increasingly to the presence of a *common understandable denominator* in the motivation of behavior generally. We have become obsessed with our complexity and do not recognize the primitive foundation that underlies it all. And this is not surprising when we realize that play, for instance, besides its educational and recreational values, already mentioned, acquires tremendous values in

prestige (which means survival in the group), and sometimes comes to be a source of livelihood as well.

Once the attention is directed to the matter we can begin to see self-preservation working in many unsuspected places, and often under forms that are opposed to one another. Activities that bring a quick relief from strain have it in common with activities that strain and struggle for future success in this or that direction. And once these facts are realized, it begins to be apparent that there is not an art, a hobby, an ideal, but what is rooted in this biological necessity, under some one or more of its great variety of forms. Spiritual values are endlessly concerned with it, defying death and fostering faith in more harmonious, enduring kinds of living. The virtues are concerned with it, making for social solidarity, and emphasizing protection, guidance and the giving and receiving of help in times of danger. Patriotism is self-preservation working overtime because the group is threatened. . . .

It is not only in the realm of positive activities, however, that self-preservation values are to a very great extent ignored. We are extremely vague about the fundamental nature of most of our negative activities as well, and often fail to see the sense of danger working even in our avoidances and hates. How many people realize, for instance, that their aversion for disorder is rooted in the feeling that there is menace in confusion—so that they either try to escape from it—as from the plague—or grit their teeth and brace themselves for an endurance test, as if disorder were advancing on them physically—like a mob—and had to be resisted? And furthermore, how many people know that their everyday embarrassments are nothing but confusion in evaluation, due to an inability to distinguish clearly the elements of danger in the situation from those of security—or an inability to distinguish different kinds of danger from one another? The danger of being exploited and the danger of giving offense are very likely to be present simultaneously, and it is only a very accurate appraisal of these elements in the immediate situation that will produce a tactful mode of self-defense. And how many people know that "difficulty," even in seemingly trivial circumstances, is often sensed as danger and reacted to as such? Or that it is always the blurred but pressing sense of danger in *any* difficult or complicated situation that causes people to escape from it and rush to something pleasanter where they can feel at ease, that is, secure?

The fact is we are accustomed to the thought of danger and self-preservation chiefly in connection with emergency—matters of life and death like accident and fire—and largely fail to recognize the self-same instinct working in its less dramatic forms.

The many unsolved problems of dislike, intensifying into hate, become more understandable when they are taken in connection with an underlying danger-sense, crudely aroused and quite unable to define its object with any degree of precision. Children feel themselves threatened very often, for example, by inadequacy or imposition on the part of adults. But since the older generation represents security *as well as* danger—and with traditional emphasis always on the former—the danger-sense is blurred and gets its only outlet in patterns of dislike, distrust and negative behavior in general.

This lack of precision in defining danger is one of the reasons why dislike and hate, once they become unleashed, tend to destroy much more than just the thing that really menaced to begin with. It is not the reason generally given—but it is the reason which points directly to the only logical control of hate, namely, through the development of a more discriminating sense of what is harmful in

the environment. Even a single step in the direction of such development would be to put our feet on the upward path that leads out of emotional confusion.

The dangers of prolonged emotional confusion are very great, as everybody knows instinctively, and they are now recognized by scientists as working havoc physically as well as mentally. The various "escapes" that serve to divert attention from the difficulty are primarily an effort to avoid this havoc. In short, we must not underestimate the basic value of any escape which succeeds in replacing the misery of a cloudy and persistent sense of danger by a sense of ease and well-being.

Unfortunately, this very genuine therapeutic value is often counterbalanced by at least two forms of consequence which such escape behavior is likely to bring. In the first place, the person who escapes habitually through distraction will never learn to cope with the disturbing situation—as is fairly well recognized in our friends, though not always in ourselves. But the second consequence is much less obvious and at the same time much more far-reaching. It is the inevitable confusion of values that results from habitual escape behavior. Comforts and distractions come to be regularly sought for various secondary reasons, obscuring recognition of the primary relationship between specific forms of security and specific forms of danger.

Escapes that cause oblivion of danger as if by magic are seldom altogether safe after the period of childhood. This is quite aside from the complicating fact that some escapes are "good" in themselves, like hobbies, and some are "bad," like drugs. The fact is, anything at all may come to be used (as an escape) to lull the sense of danger, provided it is sufficiently engrossing. The point that needs especial emphasis is this: whenever the fundamental value of escape *as such*, in providing recreation and relief from too much strain, is overlooked, the door is closed quite automatically on possibilities of coping with the original disturbance, while another door is opened simultaneously to chaos in matters of evaluation.

The fact that in escaping from one kind of danger we often run directly into others must not be allowed to blind us to the fundamental principles of motivation. Nor must we be confused by the appearances of people choosing what is harmful instead of beneficial to themselves. Whenever this occurs, we may be very certain that the situation does not look that way to them. Even the suicide, commonly cited as a glaring exception to the instinct of self-preservation, is actually escaping from some intolerable nightmare of a situation, that feels to him like an approaching doom. Then it becomes a case where one will choose the lesser of two evils, namely, an easier way to die. If you can give the would-be suicide a ray of hope for living, his reorientation in the direction of possible security will be accomplished automatically.

Just as no person wants primarily to die, so there is really no one who wants primarily to be selfish or an egotist, but no way occurs to people very often for harmonizing their own self-preservation values with those of other indivduals; and hence a great variety of reprehensible activities. Our judgment of our friends and enemies alike is greatly mellowed by introducing these biological considerations. Intolerance is the result of not appreciating how self-preservation works in other people. And it is fortunate that when we work for several ends at once—for future benefits as well as present ones—or for the group as well as for the individual—the greatest satisfaction is experienced.

Apart from this desirable effect, there is also, most fortunately, an unsuspected kind of strength that comes through

recognition by the individual of survival values in his own activities from day to day. It makes for self-respect and the emotional maturity that highly cultured people often envy in primitive personalities in whom self-preservation operates more simply and more consciously. In fact, emotional maturity depends upon such recognition, and no one has to go adventuring in adolescent fashion, searching for danger-thrills to make life interesting, who is already geared into awareness of the omnipresent questions of survival that furnish dignity and meaning to all his daily choices. Danger is always either with us or just around the corner, and the thrill of "living dangerously" comes through alertness to conditions as they actually are.

The concept of self-preservation as the source of all evaluation is radical, in going to the roots of things, but is conservative as well, for it explains and justifies all possible virtues that the human race has striven for. These virtues can be very well summed up under the general heading: *nobility of character*—which most unfortunately is not in fashion nowadays. It represents a high development of the protective instinct as found in persons who have themselves become emotionally mature.

The recognition of survival value as the basic value has a special implication for present-day democracy, which is beginning to be conscious of certain liabilities that call for serious attention. Our civilization has tricked us somehow, step by step, into an era of dangerously chaotic thinking. This danger was not obvious, however, till we were threatened by totalitarian groups which have acquired the solidarity that comes through the adoption of any common set of values. How to emerge from our confusion without resorting to pre-civilization levels is our immediate concern; how to conserve our liberty of conscience without becoming always more chaotic.

If we believers in democracy propose to go on trusting in the individual sense of values as heretofore, it is clear we must provide some standard of evaluation that all can share—and one that is beyond all controversy, because it is in line with common sense; a standard that allows for interplay between the "selfish" interests and "unselfish" ones, and introduces biological significance into the ancient and indispensable ideas of good and evil.

MYCETOZOA, ANIMAL-PLANT ORGANISMS[1]

By LLOYD G. CARR

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In the realm of "nature in miniature" there are many odd and interesting organisms worthy of special attention. Here may be placed the slime-molds or Mycetozoa, certain inhabitants of galls, unicellular algae, protozoa, and others. Most of these require optical devices for detection, but to the sharp eye the fruiting bodies of the slime-molds become at once visible.

Discovery of the fruiting bodies requires careful examination of rotten leaves or decayed logs. Moss occasionally affords an adequate base. Logs or leaves collected at the foot of a wooded incline, and leaves collected in shaded rock pockets are favorite spots. I have always been successful in locating interesting and odd forms around the sides of shaded limestone sinks. Such sinks are bowl-shaped in outline and present a gradual decline terminating in pools of water. Cliffs with out-jutting projections are usually present on the sides of the sinks. These projections afford excellent pockets in which leaves collect. In the process of decay the leaves hold much moisture and furnish a medium for the growth of bacteria. In these places and under such conditions the slime-molds thrive. Those forms fond of lime will be found particularly in the sinks, for water seeping over limestone carries with it copious quantities of dissolved calcium carbonate which easily becomes available for the slime-molds' incorporation.

Favorite spots for forms requiring little lime are shaded edges of ponds or moist ravines and hollows. Here, in leaf or stick-heaps, on rotten stumps or logs, a varied display of forms usually awaits the earnest collector. Certain forms will be found only on logs; others on leaves, whereas a few slime-molds confine themselves to more specific habitats. For instance, there are two forms that occur regularly each season on dead chestnut burrs and rarely appear elsewhere. *Arcyria globosa,* the netted slime-mold, and *Craterium concinnum,* the goblet-shaped slime-mold, select this special home.

The "fairy ring" slime-mold or *Physarum cinereum* is frequently found on lawns and has been referred to as the "lawn marvel." To see its fairy ring formation enclosing diameters of from six to eleven feet on a green background is an impressive sight. Another species that frequently turns up is the "flowers of tan" or *Fuligo septica.* It has a fondness for decayed sawdust piles where it often spreads in compact masses covering several square feet. It is readily detected by the yellow crust that envelops the small "puff-balls."

Best results are obtained in "mycetozoanizing" during the summer and fall months a few days after a rain, when almost any rotten log will furnish myriads of fruiting bodies in little fairy-like colonies.

Considering the slime-molds, which the zoologist calls Mycetozoa (fungus-animal) and the botanist Myxomycetes (slime-fungus), we are confronted with a group possessing a unique life history, structure and a variety of unusual forms. As the names applied indicate, these organisms hold affinity with both plants and animals. From the resemblance of the fruiting bodies to small puff-balls the early workers naturally

[1] My appreciation goes to Dr. Ivey F. Lewis for interest in this manuscript.

included them with the fungi, but when their life history was more completely understood through the efforts of Fries, Wallroth, de Bary, Cienkowski and Rostafinski, early pioneers in biological thought, there was doubt as to where they belong.

The change of this organism from an animal to a plant status may be noted by bringing home pieces of wood or leaves carrying the seething plasmodium, which has resulted from the fusion of germinated spores that finally produce the slimy mass of protoplasm. In almost any tract of woodland this gelatinous growth may be located. It appears rather conspicuously in its yellow, orange or white coats, trailing over leaves, bark or fern stipes, where it sometimes forms a lacy pattern. I have seen it climbing old tree trunks to prey on the rich supply of bacteria afforded by the decaying wood. By placing the wood or leaf substratum in shallow dishes which have been lined with moistened paper, we may see the protoplasm forming hundreds of little "puff-balls." First the plasmodium will become thicker and less fluid-like; then the globular bodies that finally terminate as mature sporangia will follow. Similar results may be secured by germinating the dried plasmodium or sclerotia on moist paper, with intervals of feeding on oats until fruiting ensues.

Careful examination of the structure of these bodies reveals a unique complexity and discloses to the curious observer fascinating aspects for investigation. On crushing a "puff-ball" on a slide in a drop of water, with subsequent microscopic examination, there come to view many spores variously scattered throughout the field of vision. Often these are attached to a thread-like net or capillitium that is characteristic of most of these organisms. High magnification shows delicate sculpturings on the spores. The mosaic may be a reticulate net formed by the union of numerous bands or rings, some of which are pitted. A few forms have spores with warts generally distributed over the surfaces, whereas a number have bulb-resembling protuberances.

The fruiting bodies of the netted arcyrias and hemitrichias, the goblet-shaped crateriums and the lime-knotted physarums are beautiful in color, shape and structure. They may be iridescent, approaching the hues of the rainbow, blue or green, orange, red, rose, yellow or nut brown. Their "puffballs" develop as pretzel or snake-like bodies or in groups where individual sporangia are indistinguishable, but more frequently display distinct and separate units.

External examination of the "puff-balls" presents walls that function in holding together the mass of netted threads. Occasionally there are two walls evident and sometimes three. These may be closely compressed or slightly raised over the spores. In the physarums, badhamias, didymiums, fuligos, etc., the walls are composed of crystalline lime granules. This condition results when the plasmodium at the time of fruiting discharges a copious quantity of lime in aqueous solution. Subsequent evaporation of the limy fluid segregates the granules into compact walls or layers. These may assume a stellate or spherical shape. The physarums, crateriums and fuligos possess rounded granules in their structures, while the didymiums have the stellate type.

The action involved in wall-and-"puffball" formation and granular segregation is interesting. Robert Hagelstein has described the curious phenomenon in the stellate form, *Didymium crustaceum:*[2]

The outer crust of pure lime crystals is here re-

[2] Robert Hagelstein, *Mycologia*, 30: 3, May-June, 1938.

garded as distinct and forming separately from the sporangium proper. It is very fragile, crumbling and disappearing with the slightest disturbance. When perfectly developed it is not attached to the sporangium but covers it like an inverted jar. It seems to form by the rapid evaporation and crystallization of the saturated medium containing lime in solution which is discharged by the plasmodium when it divides to form sporangia. The outer side would be smooth from surface tension. As sporangial formation proceeds within, and with consequent contraction, there would be a layer of the liquid between the outer formed crust and the forming sporangium. By evaporation, further crystalline deposits of lime would be made wherever the liquid touched, principally on the forming capillitium and spores; on the stalk, or from it to the outer crust along the habitat base; or as connecting masses between the sporangium and outer crust. These deposits may be observed in many sporangia. The confined liquid also plays an important part in the shaping of the irregular sporangia, conforming them to its pressure or the shape of the outer crust.

Dehiscence of the sporangial wall deserves special note from the artistic patterns which are formed. Often the wall falls backward in a petaloid fashion resembling the petals of a miniature water lily, as in *Diderma Treyelyani*. The goblet-shaped crateriums possess well-defined lids which open on the slightest provocation. Often while collecting we will find a number of goblets with their "caps off" and contents blown far afield.

Upon opening, the "puffballs" disclose their beautiful fluff of threads or capillitia among which the spores are scattered. These conform to a special system that may be a meshed net assuming the appearance of a window screen, or perhaps a mass of free threads without any connections to the walls may be present. In some forms the threads are assembled around a main stem, as in *Stemonitis* and *Comatrichia*. The threads in most of the forms usually show unique sculpturing.

In examining the threads of *Arcyria* and *Hemitrichia* another fascinating aspect of the slime-mold's structure is brought to light. We note that the threads of *Arcyria* are decorated with numerous cogs or spines, while *Hemitrichia* turns toward the spiraled type. The spirals are distinct and may easily be counted.

In *Trichia* we meet a capillitium composed solely of free threads haphazardly arranged in a mass. These threads when at play exercise a quick jerky, elater-like action that assists in dispersing the spores. These elaters appear as though they are wound with fine strands of yellow silk.

In the physarums, crateriums and fuligos capillitia of knots filled with rounded granules are evident. The lime-knots are colored in tints of red, orange, yellow, brown and white, being disposed in fusiform, angular or rounded groups, which are connected by hyaline threads. The picture of knots as a whole forms a fantastic and odd pattern pleasing to the artistic eye. In the badhamias there exists an irregular papery mass of lime built as jagged partitions throughout the fruiting bodies.

In our brief survey we have encountered a complex organism carrying on its existence in much the same way as higher organisms, revealing the features that associate it with life, and maintaining its status in its own sphere of unity on as high a scale of perfection as the more advanced animal and plant groups. The uniqueness of the group in representing a link between animal and plant life, through its transformation of a streaming protoplasm into hundreds of tiny "puffballs," graphically pictures the close relation of animal to plant and their connecting cord.

BOOKS ON SCIENCE FOR LAYMEN

WHEN THE EARTH SHAKES[1]

THE author of "Our Trembling Earth" is the distinguished head of the Fordham seismological observatory and chairman of an active committee on amateur seismology. The book fills a gap in the limited list of publications on earthquakes by presenting an account of the complete field of seismology in a popular and humanistic style. The layman whose knowledge of earthquakes has been limited heretofore to newspaper accounts will find much satisfaction in the present book.

The author, after summarily discussing the nature of earthquakes, explains how they are located from instrumental records. He devotes interesting pages to the geological interpretation of seismograms, and shows, with the help of reproductions of actual seismic records, how the latest knowledge of the internal constitution of the earth has been acquired. In this regard, he proposes some original theories of his own. He emphasizes the remarkable and exemplary cooperation between the observatories of individual stations, the Coast and Geodetic Survey and the Jesuit Seismological Association. The inevitable question: "Of what value is the instrumental study of earthquakes?" is answered by the author in three chapters devoted to the aims, both practical and academic, of seismology. The book closes with a discussion on amateur seismology, including instructions on how to build instruments capable of recording distant 'quakes.

Throughout the book, human interest is heightened by off-the-record stories of incidents, both happy and tragic, which break the humdrum routine of the seismologist. "Our Trembling Earth," written in a sparkling style by a scientist of wide experience, is an up-to-the-minute and remarkably complete picture of seismology.

WALTER J. RHEIN, S.J.

[1] *Our Trembling Earth.* Joseph Lynch, S.J. Illustrated. 202 pp. $3.00. 1940. Dodd, Mead and Company.

PRACTICAL AND THEORETICAL CULTURE STUDY[1]

AT last, a full exposition of the culture historical method of ethnology is available in English. Recognizing that Graebner's earlier presentation of the methods of the Graebner-Schmidt-Koppers or Vienna historical school given in "Methode der Ethnologie" (1911) was difficult even for German-speaking people to understand and evidently hoping that a comprehensive statement of its position that included answers to many criticisms would disseminate a wider comprehension and therefore acceptance of its views, Father Schmidt wrote "Handbuch der Methode der Kulturhistorischen Ethnologie" (Münster, 1937), of which the present volume is a translation by S. A. Sieber.

It is perhaps far more important in methodological considerations to recognize that use of a certain method by no means guarantees consistent results than it is to attempt criticism of that method. As a matter of fact, the quarrels between the various schools of anthropology have generally turned less upon their abstract methodological declarations than upon what they think is worth doing and what they actually do. Stripped of actual application and reduced to abstractions, contending views are usually seen not to be irreconcilable but to contribute grist to some common mill. It is somewhat astonishing that a school that has produced results that are so generally rejected in America as those of the Vienna

[1] *The Culture Historical Method of Ethnology.* Wilhelm Schmidt. XXX + 383 pp. $5.00. 1939. Fortuny's.

school should have a methodology which is almost entirely acceptable. And yet there is scarcely an assumption, hardly a point of logic in the present volume with which one will seriously disagree. Father Schmidt has expounded with incomparable, almost tedious, thoroughness every rule and subrule for reconstructing culture history. He has squarely met previous criticisms of his methods and shown that everything from archeology to functionalism and even a psychological approach is theoretically compatible with his point of view and can contribute to history. The details set forth for appraising and utilizing source materials (Chapter II) are not likely to cause disagreement. Even the means for establishing culture relations (Chapter III), kulturkreise (translated culture circles) and culture strata (Chapter IV), internal culture development (Chapter V) and culture causality (Chapter VI) contain very little that is truly controversial. No one will seriously doubt that two or more culture complexes made up of elements which are sufficiently similar (qualitative criterion) and sufficiently numerous (quantitative criterion)—"sufficiently," of course, is subject to individual interpretation—are genetically related, especially when due consideration has been given to the geographical situation of the complexes, to the "organic unity" of the cultures, to the possibility of independent invention and to other pertinent factors—all of which Father Schmidt reduces to a long series of rules. One could agree, in fact, with every word of Father Schmidt's presentation of method and yet remain no less skeptical of the historical reconstructions that he has so abundantly made and published in many other works. How is it possible that scientists can agree on abstract methodology and yet arrive at substantially different conclusions?

The answer is that no amount of methodologizing rules out a crucial element of subjective judgment—a judgment that evidently springs as much from the scientist's milieu as from his attempts to use sheer reason. As Father Schmidt directs certain criticisms and reproaches particularly at Americans, eleven of whom he singles out for comment, it is of some interest to inquire what differences exist between the American and Vienna schools.

First and foremost, Americans have been absorpt in field work in the Indian groups at their own backdoor, whereas the Vienna scientists have turned to libraries and museums for research materials. The pressure of work has not only left Americans little time for methodologizing but has minimized its importance. An American research worker obtaining materials direct from the native group or personally acquainted with those who are doing so has no more interest in a formal and comprehensive set of principles concerning the discovery, collection, meaning and criticism of sources (Chapter II, pp. 83–135, written by Koppers) than a person who has to cross the street many times daily has for rules governing each step. It is understandable that these rules should have been developed where research was mainly in the library.

But the American environment has also produced a point of view and a procedure for reconstructing history which, although infrequently stated as an abstract proposition, is fairly consistently implied in at least the better products of American research. In contrast to the kulturkreis workers, who reconstruct history on a world scale, Americans have devoted themselves to restricted tribes or areas. This is not done because, as Father Schmidt seems to contend, they have a predisposition to regard the culture area as the ultimate historical unit—to which he opposes the kulturkreis—but because of a conviction that the most reliable historical materials come from a

detailed study of the continuum of development of each local, functioning culture unit. Furthermore, Americans tend, admittedly or not, to adopt a somewhat scientific attitude, whereas Father Schmidt is frankly and thoroughly historical and nonscientific. (Even the chapter on "culture causality" regards causes as the specific antecedents of particular events, not as causal factors which, from a scientific point of view, have repeatedly produced a similar effect.) And it is significant that American historical interpretations often resemble Father Schmidt's in proportion as the authors deliberately disavow a scientific approach. The crucial difference, then, between the American and Vienna schools is that the former, making detailed studies of culture process in restricted areas, see like causes producing like effects—for example, agriculture, house types, clothing, social institutions—perhaps once in each hemisphere, perhaps many times in different localities. Thus, without disputing Father Schmidt's abstract rules, they doubt that cultural similarities in different parts of the world are usually explainable by genetic relationship and are reducible to kulturkreise and sequences.

It is evident, therefore, that the essential differences in interpreting ethnological data are no more subsumed in the formal rules presented in this volume than they are in most American theories that are presented *in vacuo*, but that they are nevertheless real and are clearly implicit in much actual research. The implication would seem to be that it is incumbent on Americans to make their own methodology more explicit but that for the present, at least, methodological declarations will be far clearer and more convincing if they are embedded in pieces of substantial research. It is almost an obligation, however, that, in clarifying their own methodology, Americans give Father Schmidt's volume the most careful consideration. It contains so much solid thought and painstaking analysis that, as Kluckhohn remarks in his Preface, "To follow the argument (often of intricately reasoned structure) surely means an enrichment of one's own perspective on techniques, methods, theory, and methodology," and, we might add, on himself.

JULIAN H. STEWARD

AN ELEMENTARY BOOK ON CONSERVATION[1]

THIS is a school text-book on conservation, superbly planned and organized, well made and illustrated. It is so written as to sustain interest throughout. Two chapters are devoted to the physical and historical background of American wastefulness which has made conservation such a live issue. The remaining seven chapters are concerned, in order, with soil, water, forest, grassland, wildlife, minerals and human resources. The balance and completeness of this treatment are admirable.

The animating idea of the book is twofold. First, conservation is an immediate and critical problem. Second, every one can do something about it. It is taught here distinctly as an activity. The principle of sustained yield is emphasized as the very heart of the conservation enterprise.

In view of the likelihood of widespread use, the reviewer hopes that publisher and authors will take occasion to revise the book soon, eliminating a number of scattered but significant blemishes. These appear particularly in the important early chapters. For example, on page 4 occurs the statement, "Natural resources by themselves exist in a friendly neighborhood of help-one-another." The idea of good-will belongs in this book, but certainly not in that context. In fact, on page 6 the authors find

[1] *This is Our Land.* E. G. Cheyney and T. Schantz-Hansen. Illustrated. 337 pp. $3.00. Webb Publishing Company.

it necessary to say, "Even when left to themselves, natural resources have frequent squabbles." This is all dangerous stuff to put into the elementary schools—particularly in a country which is suffering, as is ours, from wide-spread scientific illiteracy.

Again, in discussing the very basis of the whole problem, the balance of nature, there is not the slightest hint of the rôle played by solar energy. The soil is credited with being the source of food, by inference on page 51 even supplying carbon. Nor is the vital fact that soil represents an organized system sufficiently developed.

Elsewhere the impression is given that eastern China has been converted into desert in the past two centuries. Kentucky, West Virginia and Tennessee are catalogued as part of a region free from mountains. The ocean is likened to the Sahara desert in that it has numerous oases *below the surface;* the location and importance of plankton is ignored. The author uses the debatable distinction between renewable and unrenewable resources. Renewability depends less upon the resources than upon ourselves.

The making of text-books is serious business, in which the best of authors needs expert help from his publisher. Authors, publisher and public alike will benefit by an adequately revised edition of this excellent book.

It should be noted that Jay N. Darling, patron saint of conservation, has contributed a pungent foreword, as well as the use of his classic cartoon, "Outline of History."

PAUL B. SEARS

THE SCIENCE OF PERSONALITY FUNCTION[1]

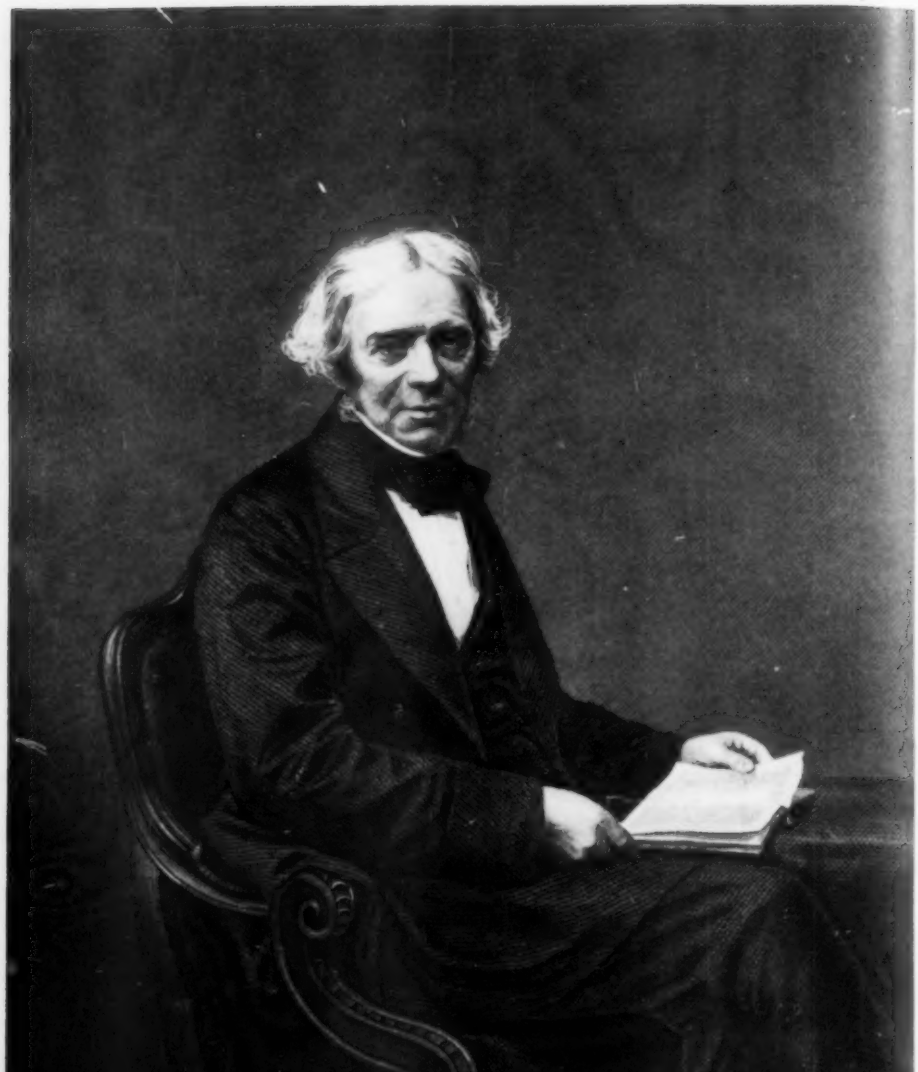
THIS text is adapted to a didactic study designed to emphasize to physicians the value of practical examination, understanding and treatment of psychological problems in general medical practice. In a study and treatment of the patient's complaints referred to organs the person as a whole has been neglected; the book, like many volumes in current psychiatric literature, utilizes the holistic and biologic approach to the disorders of personality functioning in general medicine.

Psychobiology is defined as the physiology of the individual, or the science of personality function. Life, with its properties of organization with growth, metabolism and reproduction, is studied as an "experiment of nature"; mentation has no structural representation other than the whole person and therefore can only be viewed as it is manifested in action or behavior with meaning. Overt and implicit functions of man can not be separated into that of the mind or that of the body but are integrated in the total personality organization.

Psychobiology has to do with the study of the mentally integrated functions of human beings, both normal and abnormal ones, while psychiatry is more pointed, dealing with psychopathological reactions which lead to complaint problems. The psychobiological school of thought of Adolph Meyer has introduced into psychiatry a new vocabulary: ergasia (personality at work), ergasiology (study of the functioning total organism), and ergasiatrics (study of abnormal personality reactions), which perhaps is timely. Improved methods of communication by language has been stimulating in the relatively new medical speciality of psychiatry. "Elementary psychobiology" is not for the usual elementary student. Dr. Billings's general principles of psychotherapy are conservative and based upon the broad definition of treatment of Webster's International Dictionary, *viz.*, "the management and care of a patient or the combating of his disorder."

R. H. GUTHRIE

[1] *A Handbook of Elementary Psychobiology and Psychiatry.* Edward G. Billings. xix + 271 pp. $2.00. 1939. The Macmillan Company.



MICHAEL FARADAY

ENGRAVED BY D. J. POUND FROM A PHOTOGRAPH BY MAYALL.

THE PROGRESS OF SCIENCE

MICHAEL FARADAY, 1791–1867

MICHAEL FARADAY, the son of a blacksmith, was born 150 years ago in London, England. In his youth he was apprenticed as a bookbinder, and in his early manhood he became a chemist. Among his contributions as a chemist, he liquefied several gases, he studied several alloys of steel and he produced several new kinds of optical glass. His great fame rests, however, almost entirely on his discoveries of the relations between electricity and magnetism.

It is extremely difficult now for us to understand the state of knowledge of electricity in Faraday's day. It was known that it is not conducted by glass but that it is conducted by copper, a substance several times as dense. It was long before there were any plausible explanations of how electricity is conducted through certain solid bodies. A more mystifying property of electricity is that it is related to magnetism. By 1820 Oersted was making approaches to the subject. In 1821, one hundred and twenty years ago, Faraday published his first paper on the relations between electricity and magnetism—that electric currents will produce magnetic effects in their vicinity and that magnets moving near conductors will produce electric currents in wires with which they have no physical connection. Apparently these phenomena flatly contradict the theory that physical phenomena necessarily depend upon successions of contacts of physical objects. At any rate, the observed phenomena were astonishing. Faraday not only discovered them but worked out the laws that describe their quantitative relations.

In 1831 Faraday published a paper in which he described how an electric current in one wire could generate an electric current in a suitably placed but wholly independent second wire and worked out by experiments the laws relating to currents in the two wires. These results lie at the basis of the construction and operation of electrical transformers, which are as essential for the present electric industry as are power plants and generating stations. Faraday was not alone, however, in his attacks on electrical problems. Joseph Henry, in this country, was paralleling his work in many respects. It detracts nothing from the fame of either that the other was simultaneously exploring the same mysterious and fruitful unknown regions.

How fruitful the electromagnetic theory has been! In conformity with it electricity is generated in power plants by rotating pieces of iron wrapped in wires in the neighborhood of other pieces of iron wrapped in wires. This mysterious energy travels invisibly and silently along wires, a hundred thousand horsepower along little wires suspended from towers. A bird can sit on them wholly undisturbed by the torrents of energy they carry. If the distance is far, the energy is transformed to higher voltage by equally astonishing means. Two sets of coils of wire are placed near each other, but they are not connected. The electricity flows into one coil at a certain voltage; it flows out the other at a different voltage. At some distant point it is transformed again down to a voltage that is safe to use. The distribution of industries and populations and a thousand other aspects of modern life depend upon the properties of electrical energy mentioned here.

Consider for a moment wireless communication which depends upon the same principles. Oscillating electric currents in the sending station produce corresponding electromagnetic changes in

THE EXECUTIVE COMMITTEE OF THE ASSOCIATION AT THE PHILADELPHIA MEETINGS

Standing: ROGER ADAMS, ROY E. CLAUSEN, OTIS W. CALDWELL, ESMOND R. LONG, HENRY B. WARD, GEORGE D. BIRKHOFF. *Sitting:* EDWIN G. CONKLIN, F. R. MOULTON, J. MCKEEN CATTELL, ALBERT F. BLAKESLEE AND BURTON E. LIVINGSTON

space. They move with the speed of light. Are they transmitted by or through the ether? Those are words that tend to hide our ignorance. They are reflected from the Heaviside layer, which is so high above the surface of the earth that we ordinarily would call it a vacuum. Perhaps they are reflected again, this time by the earth's surface. After repeated reflections they reach some distant wires in which they generate extremely feeble electric currents. After amplifications and transformations they may be turned into a voice from Europe or South America. These are the consequences of the electromagnetic principles Faraday discovered only about a century ago. Nearly all the applications have been developed during the past fifty years, and many of them within twenty years.

Just now we are listening with fear to the tread of Hitler's legions. After their very echoes have died away and been forgotten Faraday's contributions to the electromagnetic theory will be held in grateful remembrance and the anniversary of his birth will be noted throughout the earth, as it is now.

F. R. M.

NEW HAMPSHIRE MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MEMBERS of the American Association for the Advancement of Science and of its affiliated societies for several months looked forward with happy anticipations to the meeting they were to hold at Durham, New Hampshire, from June 23 to June 28. All their anticipations were realized. They found that the University of New Hampshire is delightfully located in a gently rolling country between the lakes and the sea; that its buildings are commodious and well appointed; and that excellent arrangements had been made to provide for the comfort of all who attended the meeting. For a few days the scientists who gathered at Durham lived peaceful and harmonious lives, almost unmindful of the tragic events that were disturbing the world.

There were only two general sessions, the first under the sponsorship of Pi Gamma Mu, the National Social Science Honor Society, at which Dr. F. R. Moulton spoke on "Our Social Order," and the second a distinguished address on "The Basis for Faith in Democracy," by Dr. Max Schoen, which was delivered under the auspices of the New Hampshire chapter of the Honor Society of Phi Kappa Phi. Pi Gamma Mu and Phi Kappa Phi sponsor addresses at summer meetings of the association, and the Society of the Sigma Xi and the United Chapters of the Phi Beta Kappa corresponding addresses at its winter meetings. These broad surveys of special fields of science and society emphasize the fact that in spite of their subdivisions and differences the natural and social sciences have the common aim of advancing human welfare.

After the close of the first general session, the University of New Hampshire tendered a reception to members of the association and of its affiliated societies and to their guests. On the fourth evening the university provided a concert in the Field House, at which a chorus of three hundred and fifty voices sang Haydn's *The Creation*. The accompaniment was by the New Hampshire Youth Orchestra of eighty pieces. Each afternoon an exhibition of motion pictures on a wide variety of scientific subjects was open to the public.

During the meeting more than two hundred formal papers and addresses were presented. They included contributions to mathematics and meteorology, discussions in the fields of geology and geography, a symposium on the chemical control of insects, a large number of

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papers on botanical subjects, a program on psychology, a series of papers on population questions in New England, eighteen papers on medical subjects, a group of papers by the American Psychiatric Association on civilian morale and a large number of papers on various problems of agronomy, forestry and horticulture. These numerous formal sessions were, however, only a part of the program of the meeting. The meteorologists joined in an excursion to the summit of Mount Washington, the highest mountain in New England. The geographers and geologists conducted a one-day field excursion for the examination of geographic and geologic features of the Durham area, and a three-day excursion through the White Mountains, including the ascent of Mount Washington, for the purpose of examining the evidence in support of the recent interpretations of some of the most complex mountain formations in the United States. Of all the scientists, the botanists took the most extensive excursions. They not only visited the White Mountains and Mount Washington, but also most of Maine. The phytopathologists visited plant research laboratories and experiment stations in various parts of Connecticut. The Torrey Botanical Club, the Ecological Society of America and other societies joined in excursions to Mount Monadnock, Spruce Hole, Cedar Swamp and other interesting localities. The agronomists, the foresters and the horticulturists participated in many field trips to points of special interest to themselves.

As interesting and enjoyable as the excursions and field trips were, they were not simply pleasant outings. On the contrary, they were taken with serious purposes and undoubtedly contributed as much to the advancement of science as would an equal number of days devoted to listening to reports on scientific investigations. It is a characteristic of

THOMPSON HALL, ADMINISTRATION BUILDING OF THE UNIVERSITY OF NEW HAMPSHIRE

HAMILTON SMITH LIBRARY OF THE UNIVERSITY OF NEW HAMPSHIRE

science that it generally combines work and pleasure, and often the happiest hours of a scientist are his most strenuous.

In the case of the section on the social and economic sciences the program consisted entirely of sessions for the presentation of papers. The general themes of the six sessions of this group were the origins of the peoples of New England and their social and political problems. Too often it is carelessly assumed that the present people of New England are the descendants of the Pilgrims and other early settlers. As a matter of fact, later immigrations of Irish, French Canadians, Italians and many other peoples have entirely changed the picture. The many interesting consequences of these almost unparalleled transformations of populations in one of the oldest sections of our country were discussed in a series of very distinguished papers. Their publication would be an important contribution to an understanding of present New England.

F. R. Moulton,
Permanent Secretary

PRESENTATION OF THE MEYER MEDAL TO DR. EDMUNDO NAVARRO DE ANDRADE

In recognition of his outstanding accomplishments in the introduction and utilization of Eucalyptus in Brazil, the council of the American Genetic Association has awarded Dr. Edmundo Navarro de Andrade the Meyer Medal. It was presented at the U. S. Plant Introduction Station at Glenn Dale, Maryland, on the afternoon of June 2. Dr. Navarro is the seventeenth plant explorer to be awarded the Meyer Medal, which was established in 1919, in memory of Frank N. Meyer, who for many years combed far corners of China to find new plants for American farms and gardens.

DR. EDMUNDO NAVARRO DE ANDRADE

A EUCALYPTUS FOREST
IN SÃO CARLOS. THE TREES ON THE LEFT SIDE OF THE ROAD ARE ELEVEN YEARS OLD; THOSE ON THE RIGHT ARE TWO YEARS OLDER.

In making the presentation in behalf of the council of the American Genetic Association, Mr. B. Y. Morrison, head of the plant introduction service of the U. S. Department of Agriculture, said that fortunately not only the plant immigrants travel, but the people who are concerned with their wanderings as well. Thus the small group of plant explorers and experimenters with new plants all over the world represent a very delightful and in such a time of stress, a very important bond between the nations. Furthermore in so uncertain a world, this brotherhood of plantsmen have as their common interest something real and relatively solid and unchanging—the living plants themselves, rather than symbolisms and abstractions. In building bridges of closer relationship between the Americas such solid bonds are to-day most valuable.

Following the award Dr. Navarro gave an evening lecture at the auditorium of the Cosmos Club in Washington. Here he told in some detail his experiments and experiences with Eucalyptus in Brazil. He graduated from the University of Coimbra in Portugal in 1903, and later that year was appointed by Antonio Prado, president of the Paulista Railroad, to find ways to meet the fuel needs of the railroad. Since wood is used for fuel on most of the Brazilian railroads, Prado saw that the improvident use of the forests for fuel was eventually going to be disastrous unless growth and utilization could be balanced. To solve this problem he established a forestry section and put Navarro in charge of it.

To determine which species of trees grew most rapidly in São Paulo, Navarro established extensive tree plantings with over a hundred species of the most promising native Brazilian trees, and with as many introduced trees as he could lay his hands on. Among these were some Eucalyptus Navarro had brought back with him from Portugal;

THE MEYER MEDAL OF THE AMERICAN GENETIC ASSOCIATION

Left: ON THE LEFT IS A WHITE-BARKED PINE CONE AND ON THE RIGHT A FRUITING BRANCH OF THE CHINESE JUJUBE. THE CHINESE INSCRIPTION IS "IN THE GLORIOUS LUXURIANCE OF THE HUNDRED PLANTS HE TAKES DELIGHT." *Right:* A SCENE DEPICTING QUEEN HATSHEPSUT'S EXPEDITION TO THE LAND OF PUNT.

others were obtained from California and South Africa, and later many more from Australia. Of all the trees tested the best of the eucalypts far outgrew all competitors.

In order to get the best adapted species Navarro visited the United States in 1910, and three years later the homeland of the genus, Australia. There he received the cordial help of Professor J. H. Maiden, the acknowledged world authority on this genus. He was able under Professor Maiden's guidance to round out his already wide knowledge of the genus. As a result of these journeys Navarro established at the Rio Claro Station in São Paulo an arboretum containing 123 species of Eucalyptus, the most extensive collection of trees of this genus to be found anywhere in the world.

Through mass plantings under varied conditions Navarro chose about two dozen species which were best adapted for forest planting in Brazil. When he undertook to gain support for this project to balance Brazil's firewood budget he was met with almost fanatical opposition, an intense botanical chauvinism which denied that any imported tree could possibly be as good for any purpose as some of the numerous native trees of Brazil. Appeals to experiments on a large scale proving that the yield per acre-year of Eucalyptus wood far exceeded that of other trees only shifted the attack to other points—the wood would not burn, the smoke would injure or asphyxiate the locomotive crews, etc. As for using Eucalyptus for any other purpose, preposterous! The campaign of demonstration and education to prove the falsity of these objections took longer than the experiments to determine the best species in the first place. This is all the more curious because coffee, the premier money-crop of Brazil, is itself a plant immigrant.

In recent years Dr. Navarro's long fight for the acceptance of Eucalyptus has silenced effective opposition. The Paulista Railroad, which sponsored the first experiments, has led in putting these experiments to work. To-day this railroad has seventeen huge Eucalyptus forests totalling 21 million trees, with projected additional plantings at the rate of two million trees a year until a total of 35 million is reached. This will meet the fuel needs of the 1,800 miles of

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EUCALYPTUS IN SAO CARLOS—SEVENTEEN MONTHS OLD

wood-burning line maintained by the Paulista Company. Other Brazilian railroads and other large users of firewood and timber have followed suit, and today forests of over a hundred million Eucalyptus trees have greatly changed the landscape in parts of the state of São Paulo; and the Eucalyptus population of the rest of Brazil totals at least another hundred million trees. The necessity of plantings for future use has been recognized in a recently enacted Brazilian law which requires that all large users of wood for fuel maintain reforestation projects, with annual plantings large enough to meet at least part of the needs.

The rate of growth of the best adapted species of Eucalyptus is amazing. Growth of six feet the first year is not unusual, with equally rapid gains in height the second and the third years. One instance of over five meters growth (17 ± ft.) was recorded of a seedling set out only six months before. Plantings to be used for fuel are cut the seventh year, by which time the trunks are large enough to be used for fence posts. Trees fifteen years old are large enough for telegraph poles, and twenty-five year old trees yield railroad ties. The wood resists decay well, though it is usually chemically treated when used as posts or as railroad ties.

In recognizing Dr. Navarro's long fight to gain acceptance of the Eucalyptus in Brazil, the award of the Meyer Medal calls attention to a unique and outstanding chapter in plant introduction. Curiously enough it also may be a lead to a new use of Eucalyptus in this country. São Paulo has a climate much like Florida and other southeastern states, where reforestation is a serious problem. The species which Dr. Navarro has found best in Brazil should perhaps be tried in our own southeast, where even less spectacular growth might still make them very useful.

ROBERT COOK

CONFERENCE ON MOLECULAR STRUCTURE

A NUMBER of men of science interested in the structure of molecules[1] were invited by the Graduate School of Ohio State University to meet there for a conference during the last week of June. The topics discussed comprised the electronic structure of molecules; their rotational and vibrational motion; the application of our knowledge of these to the explanation and prediction of the thermodynamic behavior of gases and liquids; and the extension of our knowledge from atoms and diatomic molecules first to the simpler polyatomic molecules, and then to large, and even "giant" molecules. Reviews were made of our present information, and accounts were given of work in progress.

The electronic structure of atoms and of ions both in their normal and in their excited states and their behavior in collisions and in interaction with radiation are now very well understood. Mathematical difficulties in the application of quantum theory make exact prediction of their properties from theory alone hardly possible; but approximate methods, fitting into deductions from their observed spectra, make our knowledge nearly complete and leave no doubt that the theoretical laws are capable of explaining the observations.

For molecules the position is not so satisfactory. Exact quantitative theoretical predictions can only be made in the simplest cases; while theory predicts, for instance, that a neutral molecule made up of three hydrogen atoms would be unstable and could have only a transitory existence, but that the corresponding molecular ion with a single positive charge would be stable, requiring more than 184 kilocalories of energy per mole to break it up; this last result may be too small by 20 per cent. While the exact results obtained in the simplest cases, *e.g.*, the hydrogen molecule, H_2, leave no doubt that the theoretical laws are adequate; in complicated cases only semi-quantitative, semi-empirical results, based partly on rough theoretical approximations, partly on observation, are possible.

Much work of this kind has been done by various authors especially for diatomic molecules for many of which the spectra have been for a long time adequately analyzed. This work has recently been extended to cover the properties of many molecules in detail, in excited as well as in normal states. Improvements in the dispersion of the spectra have recently led to the analysis of the electronic as well as the rotation-vibration spectra of some triatomic molecules, such as nitric oxide, NO_2, and carbon dioxide, CO_2, and it is probable that in the next few years we shall have information which will enable us to predict and explain in detail the kinetics of the interaction of many such molecules.

The most interesting recent work on rotation-vibration spectra has been on molecules showing peculiar effects; such as ammonia, NH_3, for which we may regard the nitrogen atom as staying near the point of a pyramid on one side of the base composed of the three hydrogen atoms as long as the vibrations are of small amplitude, but as oscillating from one side to the other for vibrations of larger amplitude; and as some simple organic molecules, parts of which can rotate more or less freely relative to the rest; for example, the kind of internal motion shown by the molecules of alcohol, CH_3COOH, is now under discussion. Better knowledge of the internal motions is necessary in order to predict the thermodynamic behavior of these and of more complicated organic molecules.

[1] Professor David M. Dennison, University of Michigan; Professor Henry Eyring, Princeton University; Professor S. Herzberg, University of Saskatchewan, and Professor Robert Mulliken, University of Chicago, presented papers; Professor E. Bright Wilson, Harvard University, was at the last moment unable to come; his paper was read by Dr. Donna Price.

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A SMALL PART OF A MODEL OF A RUBBER MOLECULE

THE GOAL OF MOLECULAR STRUCTURE THEORY, STILL FAR OFF, IS TO EXPLAIN IN DETAIL THE PROPERTIES OF KNOWN MOLECULES SUCH AS THAT OF RUBBER AND TO PREDICT THE PROPERTIES OF SIMILAR BUT UNKNOWN MOLECULES.

This behavior, which often can not easily be observed, may sometimes be important for industrial applications.

Satisfactory methods for computing the thermodynamic properties from pure theoretical predictions and from spectroscopic data for simple molecules have been in use for some time; the extension of these to the more complicated and to the larger molecules is now in progress, and it is a reasonable hope that before long we shall be able to predict very well any reactions between not too complicated molecules in the gaseous phase. Larger molecules, however, usually break up when they are vaporized; the important reactions are most often those occurring in the liquid phase. Until the last few years almost no progress had been made in the theory of liquids (apart from rather dilute solutions in which the solutes behaved nearly like gases). Good progress in this direction is now being made; in particular the picture of a liquid as, thermodynamically, a mixture of about 86 per cent. solid and 14 per cent. gas, seems to give remarkably good results; this work can even be extended to large molecules of the form of long chains which can be regarded almost as worming their way past each other into the 14 per cent. of nearly empty space.

Progress in the next few years should be rapid. Improvements in spectroscopic equipment and technique are permitting the resolution and analysis of the spectra of more and more complicated molecules; and improvement in mathematical methods of applying theory enable explanations to be given and predictions to be made first on a rough semi-quantitative, semi-empirical basis; capable, however, of being refined, so far only for the simplest molecules, to give accurate quantitative results.

L. H. THOMAS

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TELEPHONE BY-PRODUCTS

IT is 65 years since the first sentence of speech was transmitted by telephone, and Alexander Graham Bell was granted the first patent for his unusual instrument. Six years later, the first conversation was held over long distance lines between New York and Boston, and in 1926 a public test was made of two-way transoceanic radio telephony between New York and London. All these achievements in the communications field occurred in March, and it was on the third of this month that Bell was born in Scotland in 1847.

By his invention, Bell not only gave the world one of its most important conveniences, but he also laid the foundation for the development of numerous other instruments.

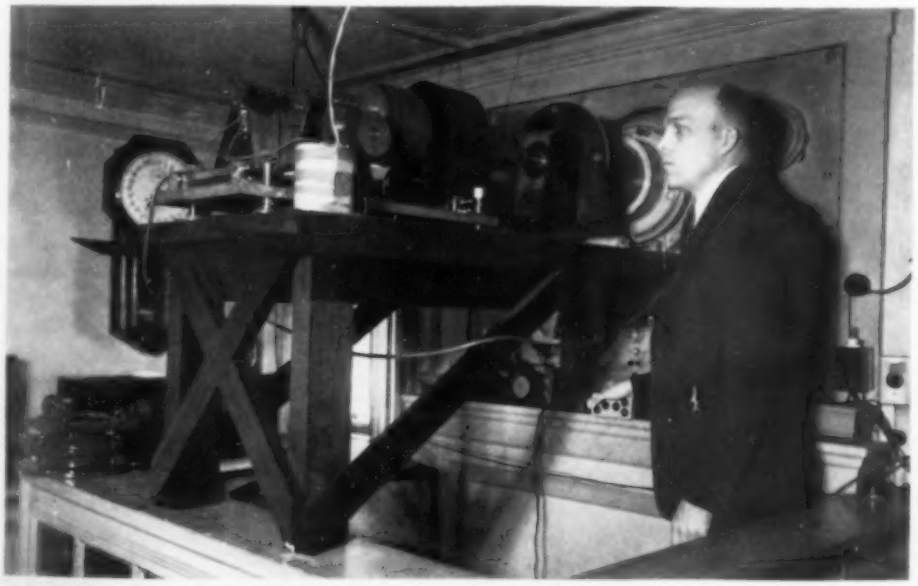
One of the most interesting examples of the importance of the telephone is its tie-in with radio. "This program origi-

nated in our Hollywood studios" is a familiar phrase. Or one may hear a news round-up from many cities, such as New York, Washington, Chicago, San Francisco, all within fifteen minutes. The shift back and forth between these cities is so rapid it is unnoticeable. Quite naturally many listeners think that all the voices they hear are coming directly through the air to their radios, but that is not what happens. Actually these voices are relayed across the country over telephone wires to radio stations in different cities. Then they are relayed again to transmitters where they are put on the air. So the distance they come through the air to your radio depends on how far you live from the transmitter, which may be 5, 50 or 500 miles.

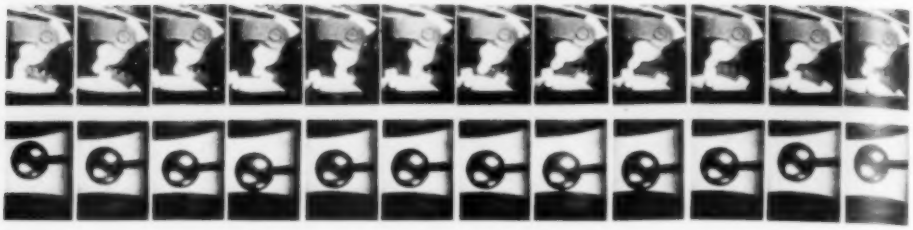
As an aid to the airplane industry, airway traffic control centers have been established in the larger airports of the country. In addition to telephone landlines, radio-telephone circuits are kept very busy here because these centers regulate the movement of planes at the airport. There are also operators who keep in constant communication with the control tower, the weather bureau, other airports and the dispatchers' offices of the different airlines.

A steel tape recorder for giving weather reports has been developed, which enables a person to learn the report merely by dialing a number in New York City, and listening to its message for 25 seconds. These reports, compiled by the New York Weather Bureau, are transmitted to the telephone office where they are recorded on machines. This device has greatly relieved the telephone operators at the Weather Bureau, for one machine can handle 30,000 consecutive calls a day. There is a similar method for obtaining the time; these services are also available in other large cities of the nation.

At both the San Francisco and the New York World's Fairs, there were two exhibits in the Bell Telephone building which were unusually popular. One was the "Voice Mirror" in which you talked into a telephone, and then listened to your words come back. These have been installed in many department stores to



APPARATUS FOR STUDYING THE CORONA OF THE SUN



PHOTOGRAPH OF RAPID MECHANICAL MOVEMENT

TAKEN WITH HIGH-SPEED CAMERA AT RATE OF 2,000 PICTURES A SECOND. *Above:* THE ACTION OF THE IMPULSE WHEEL, PAWL AND SNUBBING SPRING IN A TELEPHONE DIAL. *Below:* THE ACTION OF THE CLAPPER STRIKING THE GONG.

train the voices of their personnel, and singers find it helpful in learning their mistakes while practising the scales. The other was the hearing test equipment which over 1,500,000 visitors used in 1939. A survey was made of these tests, and there were interesting results as to the difference in hearing acuity between men and women, people of varied ages and those living in different localities. It is believed in the future such tests will be routine in physical examinations so that early symptoms of deafness will be recognized. Both of these machines are on permanent exhibition at the Franklin Institute in Philadelphia.

To achieve telephone privacy to all parts of the world, an apparatus has been devised which twists the vowels and consonants around, making a speech wholly unintelligible. To fully understand this strange method, let us trace the call a man is making from New York to London. He picks up the telephone and speaks his message as though he were just calling a neighbor. It then goes to the Overseas Transmitting Station in Lawrenceville, N. J., where it passes through the apparatus which scrambles the vowels and consonants, and is sent out on the air. In the office in London there is another device which unscrambles the inverted sounds into plain, understandable words.

While these experiments for the betterment of telephone service have been going on, there have been times when the workers have made developments which can also be used in other branches of science, and seem at first to have little connection with the telephone industry.

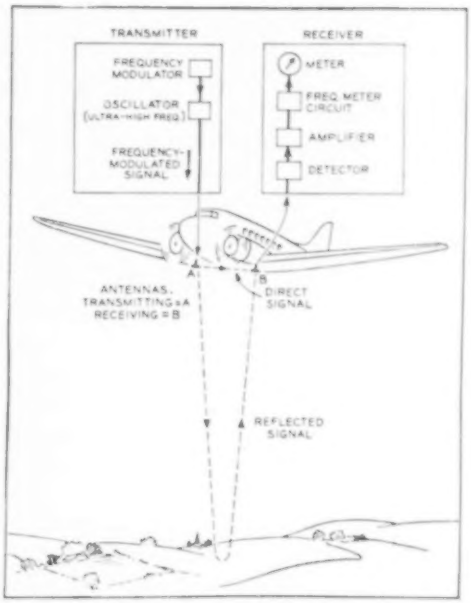
For a number of years, scientists have known that spots on the sun have interfered with clear radio reception, and have caused disturbances in other electrical industries. They wanted to see more of the corona—the atmosphere around the sun. The only time this could be seen was during a total eclipse. So the Bell Laboratories invented a machine called the Coronaviser, which was tried out last year at the Cook Observatory of the University of Pennsylvania. There will be even greater chances for making observations of the sun's atmosphere when this instrument is used with a powerful telescope on a mountain top, and plans for this are nearly completed at the McDonald Observatory on Mt. Locke in Texas.

Telephone researchers have contributed to the development of modern ultra-high speed photography. One camera, taking 4,000 pictures a second, has a small glass cube instead of a shutter. It rotates on a ball-bearing shaft between the lens and the film 1,000 times a second when used at high speed. For the intense lighting illumination which is needed, carbon arcs and tungsten lamps are used; liquid filters absorb nearly all the heat they radiate. This type of photography has been used

widely in many industries for analyzing defects in machinery, for studying vibrations in motors, and for investigating propeller design and performance in airplanes. Results have been decided in athletic events by this camera, and recently experiments have been made to study muscular and nervous reactions under varied conditions. After taking these motion pictures at such rapid speeds, they are projected at low speed.

To prevent planes from crashing into mountain tops because of miscalculation of their altitudes, the Terrain Clearance Indicator has been of much help to pilots. Previously all they had was an instrument which gave height above sea-level, and from this it was necessary to figure out the height above the ground. The indicator is really a radio altimeter which gives continuously a measurement of the distance between the plane and the earth. While flying over a city where there are skyscrapers and low buildings, there will be rapid fluctuations on the meter depending on the height of the obstructions. A very short radio wave is projected and reflected back and forth from the plane to the earth's surface or buildings. The reflected wave is made to differ from the projected wave, and the difference is indicated on a frequency meter. This instrument is also very useful as a position indicator when a pilot is approaching an airport which is near a large building.

In the medical field, there have been two noteworthy developments. The artificial larynx has restored the power of speech to many people who were either mutes or who have lost the use of their vocal cords. The apparatus consists of a thin metal "reed" attached to a rubber tube at one end with a small opening at the other. This metal "reed" is set in motion when the person blows air from his lungs through the apparatus. The vibration stops and starts the flow of air, and makes a series of sound



METHOD OF OBTAINING HEIGHT
USING THE TERRAIN CLEARANCE INDICATOR.

waves similar to those made by the human vocal cords. He goes through the usual motions of speaking with his tongue and lips, and the speech sounds are made by the resonating action of the mouth, throat and nasal cavities. By faithful practice, a person can become an expert at using this device and once more function as a normal, independent citizen. The other is a portable stethoscope which fits into a small case just a foot long, and can be carried around by the general practitioner. With this instrument the sound of the heartbeat can be increased 100 times more than with the acoustic stethoscope. It consists primarily of a magnetic "pick up" and receiver and a two-stage amplifier operated by dry batteries. It is valuable for doctors whose hearing is impaired, and for demonstration purposes when the physician is explaining to students the causes and differences in the heartbeats. Also it becomes an aid in prescribing for the treatment of those suffering from symptoms of heart disease.

EMILY DUANE WALLACE

FEDERAL OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

COORDINATION of all scientific activities concerned with national defense is the objective of the new Office of Scientific Research and Development which has been created within the Office of Emergency Management by executive order of President Roosevelt. Under the directorship of Dr. Vannevar Bush, president of the Carnegie Institution of Washington and until now chairman of the National Defense Research Committee, the new organization will serve as liaison agency for a number of scientific groups which have hitherto worked independently of each other, reporting directly to the President.

Funds for the promotion of scientific research programs for the production of new weapons and defense materials and methods, and for medical research programs having defense value, are provided by Congressional appropriation. The new Office of Scientific Research and Development is authorized to "initiate and support" such programs. This is a long step forward, for similar bodies set up during previous national emergencies have had only advisory capacity, and could not undertake research programs or other activities on their own initiative. Dr. Bush indicated his intention to "lean heavily" upon these older advisory bodies, particularly the National Academy of Sciences and the National Research Council.

In carrying on the activities authorized by the new executive order, one of the principal disbursing and action agencies will be the already existing National Defense Research Committee, of which President James B. Conant has been appointed chairman, succeeding Dr. Bush. It is understood that Dr. Conant's duties will be such that he can carry them out without neglecting his work as a university president.

Other agencies already functioning that will report to the President through Dr. Bush include the National Advisory Committee for Aeronautics, the National Inventors Council and the Health and Medical Committee established by order of the Council of National Defense. Distinctly defense activities of established bureaus in government departments, such as the Bureau of Mines and the National Bureau of Standards, will also come within the purview of the new Office of Scientific Research and Development.

Somewhat similar action was taken in Britain some time ago, when a single coordinating body was appointed to act as liaison agency between the government and about half-a-hundred research groups in various British defense organizations, both military and civil.

Close cooperation is provided for, between British and American research bodies. Britain already has an office in this country, and when Dr. Conant was in England recently he set up a similar office there, which is now taken over by the new Office of Scientific Research and Development. British scientists have requested their American colleagues to take over certain basic scientific research, especially in the field of medicine, in order that they may devote their attention more intensively to immediately pressing practical problems.

The new Office of Scientific Research and Development will also mesh closely with the Office of Production Management under William S. Knudsen and the Office of Civilian Defense under Fiorello LaGuardia. The function of Dr. Bush's organization for them, as for the Army and Navy, will be to find useful scientific methods, devices and materials, which these agencies of application can take over, produce and put into use.—*Science Service.*